HARMSWORTH SELF-EDUCATOR

1906

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A KEY TO THE HARMSWORTH SELF-EDUCATOR

At the heading of each article in the SELF-EDUCATOR is the number of the group to which the article belongs, and a reference to this key indicates precisely the place of the article in the scheme of the book. This key, therefore, enables the student at any time to understand what has preceded and what is to follow any part of the work to which he may happen to turn.

GROUP 1.

Agriculture. Beekeeping. Gardening.

FARMING. In all its Branches. Dairying. Poultry.
BEEKEEPING. A Practical and Commercial Course.
GARDENING. How to Get the Most out of a Minimum of Land. Gardening for Pleasure and Profit. Market Gardening.

GROUP 2.

Art. Architecture. Glass. Earthenware. Carving.

ART. Theory. History. Painting. Sculpture. Training of an Artist.
ARCHITECTURE. Theory. Styles. Architect's Training.
GLASS AND EARTHENWARE. Including Pottery.
CARVING. Wood. Stone. Ivory. Horn. Tortoiseshell.

GROUP 3.

Biology. Psychology. Sociology. Philosophy. Religion.

BIOLOGY. Including Evolution. Palæontology. Zoology. Anthropology. Ethnology. Heredity.
PSYCHOLOGY. Including Psychical Research.
SOCIOLOGY. Including Political Economy.
PHILOSOPHY AND RELIGION. History and Systems. Christianity.

GROUP 4.

Building. Cabinet Making. Upholstering. Furnishing. Fire.

BUILDING. Excavating. Drainage. Manufacture of Bricks, Limes, and Cements. Bricklaying. Clay Wares. Reinforced Concrete. Masonry. Carpentry. Slates and Tiles. Plumbing. Joinery. Foundry and Smiths' Work. Painting. Paper Hanging and Glazing. Heating, Lighting, and Ventilation. Building Regulations. Building Abroad. In Business as a Builder.
CABINET MAKING, UPHOLSTERING AND FURNISHING.
FIRE. Fireproof Materials. Fire Prevention. Fire Extinction.

GROUP 5.

Chemistry and Applied Chemistry.

CHEMISTRY. Inorganic and Organic. Chemistry of the Stars.
APPLIED CHEMISTRY. Acids and Alkalies. Oils (Fixed Oils and Fats; Waxes; Essential Oils and Perfumes; Paints and Polishes). Candles. Soaps. Glycerine. Glues and Adhesives. Starch. Inks. Tar and Wood Distillation. Cement and Limes. Matches. Celluloid. Manure. Waste Products. Petroleum. Paper Making (including Paper Staining and Uses of Paper). Photography.

GROUP 6.

Civil Service. Army and Navy.

CIVIL SERVICE. Municipal. National. Imperial.
ARMY AND NAVY. How to Enter Them.

GROUP 7.

Clerkship and the Professions.

CLERKSHIP AND ACCOUNTANCY. Complete Training. Bookkeeping.
BANKING. The Whole Practice of Banking.
INSURANCE. Life, Fire, Accident, Marine.
AUCTIONEERING AND VALUING. Practical Training.
ESTATE AGENCY. Departments and Officials of a Great Estate. Training a Land Agent.
MEDICINE. Training of a Doctor. Specialists. Veterinary Surgeons. Chemists and Druggists. Dentistry; The Dental Mechanic. Home and Professional Nursing.
CHURCH. How to Enter the Ministry of all Denominations.
SCHOLASTIC. Teachers, Professorships, Governesses, Coaches, Tutors. Secretaries, etc. Institution Officials. Political Organisations. Lecturers.
LAW. Solicitors and Barristers. Personal and Commercial Law.

GROUP 8.

Drawing and Design.

DRAWING. Freehand. Object. Geometrical. Brush. Memory. Light and Shade.
TECHNICAL DRAWING. For Engineers; Coppersmiths, Tinmen, Boilermakers; Architects; Stonemasons; Carpenters and Joiners; Plumbers.
DESIGN. Book Decoration. Textiles. Wall Papers. Metal Work.

GROUP 9.

Dress.

DRESS. Dressmaking. Underclothing. Children's Clothing. Tailoring. Millinery. Men's Hats. Furs and Furriers. Feathers. Shirts and Collars.

GROUP 10.

Electricity.

ELECTRICITY. Electrical Engineering. Telegraphs and Telephones. Illuminating operations, etc. Cables and Insulated Wire. In Business as an Electrical Engineer.

GROUP 11.

Civil Engineering.

CIVIL ENGINEERING. Surveying. Varieties of Construction. Machines Employed. Roads. Bridges. Tramways. Railways. Water Supply. Sewerage. Rivers. Hydraulics. Pumps. Harbours. Docks. Lighthouses. Foreign Work. In Business as a Civil Engineer.

GROUP 12.

Mechanical Engineering. Military Engineering. Arms & Ammunition.

MECHANICAL ENGINEERING. Applied Mechanics. Workshop Practice. Tools (Hand and Machine). Machine Tools. Portable Machine Tools. Machines and Appliances (A General Guide to Construction). Clocks and Watches. Scientific Instruments.
MILITARY ENGINEERING. Pontoons. Bridges. Fortifications. Rafts. Trenches. Fording Rivers. Conditions in Peace and War.
ARMS AND AMMUNITION. Manufacture of Arms and Explosives.

GROUP 13.

Geography. Astronomy.

GEOGRAPHY. Physical. Political. Human. Commercial.
ASTRONOMY. A Survey of the Solar System.

GROUP 14.

Geology. Mining. Metals and Minerals. Gas.

GEOLOGY. A Course in Geology.
MINING. The Practice of Mining; Coal, Gold, Diamonds, Tin, etc.
METALS. Metallurgy. Iron and Steel. Iron and Steel Manufactures. Metal Work. Cutlery.
MINERALS. Mineralogy. Properties of Minerals.
GAS. Manufacture of Gas.

GROUP 15.

History.

HISTORY. A Short History of the World.

GROUP 16.

Housekeeping and Food Supply.

SERVANTS. Qualifications and Duties of Every Kind of Servant.
COOKERY. A Practical Course.
LAUNDRY WORK. Washing. The Laundry as a Business.
FOODS AND BEVERAGES. Milling. Bread-making. Biscuits and Confectionery. Sugar. Condiments. Fruit. Fisheries. Food Preservation. Catering. Brewing. Wines and Ciders. Mineral Water. Tea. Coffee. Chocolate. Cocoa.

GROUP 17.

Ideas.

IDEAS. The Power of Ideas in Life. Brains in Business.
PATENTS AND INVENTIONS. How to Protect an Idea.
APPLIED EDUCATION. Application of Education in Every

GROUP 18.

Languages.

LATIN. ENGLISH. FRENCH. GERMAN. SPANISH. ITALIAN.

GROUP 19.

Literature. Journalism. Printing. Publishing. Libraries.

LITERATURE. A Survey of the World's Great Books and their Writers. Poetry. Classics. Fiction. Miscellaneous. How to Read and Write.
JOURNALISM. A Guide to Newspaper Work, with Practical Training.
PRINTING. Composing by Hand and Machine. Type Cutting and Founding. Engraving and Blocks. Bookbinding and Publishing.
LIBRARIES. Officials and Management of Libraries.

GROUP 20.

Materials and Structures. Leather. Wood Working.

MATERIALS. The Characteristics and Strength of Materials.
STRUCTURES. The Stability of Structures.
LEATHER. Leather Industry. Leather Belts. Boots and Shoes. Saddlery and Harness. Gloves. Sundry Leather Goods.
WOOD WORKING. Design and Operation of Wood Working Machinery. Wood Turning. Miscellaneous Woodwork.

GROUP 21.

Mathematics.

MATHEMATICS. Arithmetic. Algebra. Plane Trigonometry. Conic Sections.

GROUP 22.

Music. Singing. Amusement.

MUSIC. Musical Theory. Tonic Sol-fa. Tuition in all Instruments. Orchestration. Conducting. Bell Ringing. Manufacture of Musical Instruments.
SINGING. The Voice and Its Treatment.
AMUSEMENT. Drama and Stage. Business side of Amusement. Sports Officials.

GROUP 23.

Natural History. Applied Botany. Bacteriology. Natural Products.

NATURAL HISTORY. Kingdom of Nature. Its Marvels, Mechanism, and Romance. Animal Life. Flowers. Plants. Seeds. Trees, Ferns, Mosses, etc.
APPLIED BOTANY. Tobacco (Tobacco Pipes). Forestry. Rubber and Gutta Percha. Basket and Brush Making. Cane Work. Barks (Cork, Wattle).
BACTERIOLOGY. Pathological and Economic.
NATURAL PRODUCTS. Sources. Values. Cultivation.

GROUP 24.

Physics. Power. Prime Movers.

PHYSICS. A Complete Course in the Science of Matter and Motion.
POWER. A General Survey of Power. Natural Sources. Liquid and Compressed Air.
PRIME MOVERS. Engines. Steam. Gas. Heat. Turbines. Windmills.

GROUP 25.

Physiology. Health. Ill-health.

PHYSIOLOGY. Plan of the Body. Digestive, Circulatory, Respiratory, Locomotor and Nervous Systems. The Senses.
HEALTH. The Five Laws of Health. Personal Hygiene. Environment. State Medicine and the Public Health.
ILL-HEALTH. General Ill-health. Its Special Forms. Common Ailments and Domestic Remedies.

GROUP 26.

Shopkeeping. Business Management. Publicity.

SHOPKEEPING. A Practical Guide to the Keeping of all Kinds of Shops.
BUSINESS MANAGEMENT. The Application of System in Business.
PUBLICITY. Advertising from all Points of View. As a Business.

GROUP 27.

Shorthand and Typewriting.

SHORTHAND. Taught by Pitmans. TYPEWRITING. Working and Management of all Machines.

GROUP 28.

Textiles and Dyeing.

TEXTILES. The Textile Trades from Beginning to End.
DYEING. Dyes and Their Application.

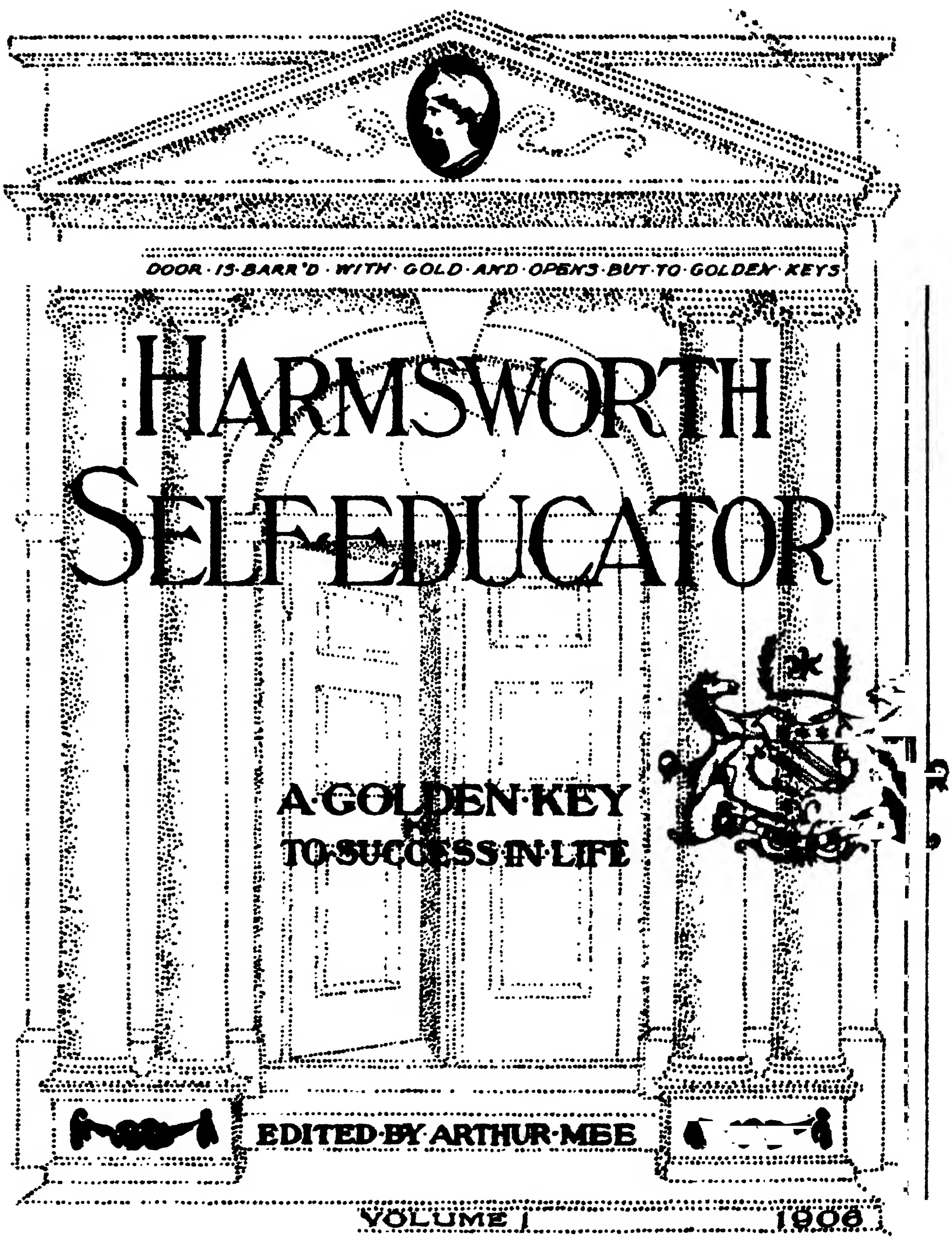
GROUP 29.

Travel and Transit.

TRAVEL. How to See the World. The Business Side of Travel.
TRANSIT. A General Survey of Means of Communication.
VEHICLES. The Construction of Air, Land and Sea Vehicles.
RAILWAYS. The Management and Control of Railways.
SHIPS. Shipbuilding. Shipping. Management of Ships.

THE BIRTH OF BRITISH COMMERCE

[illegible]ANS TRADING WITH THE EARLY BRITONS ON THE COAST OF CORNWALL."


DOOR · IS · BARR'D · WITH · GOLD · AND · OPENS · BUT · TO · GOLDEN · KEYS
HARMSWORTH
SELF EDUCATOR
A · GOLDEN · KEY
TO · SUCCESS · IN · LIFE
EDITED · BY · ARTHUR · MEE
VOLUME I
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CONTENTS OF THIS VOLUME

THE PURPOSE AND PLAN OF THE SELF-EDUCATOR

By THE EDITOR

THE HARMSWORTH SELF-EDUCATOR is designed to be a working school of life. Its purpose is to lay the foundations of an adaptable and successful career for the thousands of young men and women who are bewildered by the increasing difficulty of choosing a definite aim in life, or, having a definite aim, of adapting themselves to its conditions.

It is a difficulty which grows with the growing complexity of life. As science throws open new worlds to conquer, as research reveals new fields of investigation, as education changes old methods for new, the problem of what to do with life becomes more insistent in youth and more perplexing to those in whose hands the moulding of a new generation lies.

Minds, not Machines. It is the purpose of the SELF-EDUCATOR to help to solve the problem which arrests attention and demands solution in nearly all our lives. It is a part of the Idea of Life which produces the EDUCATOR that to live life whole we must understand life whole. Dr. Fitchett has put the truth forcefully and eloquently in his contribution to these pages. It is impossible for any one of us to think of ourselves as separate units, isolated and disconnected members of the human race. Not one stone is separated from another; not one petal of the lily of the field can open to the sun without the working of a thousand laws. And not one of us can do our work well in the world unless every aspect of it has its place in our sympathy and in our education. It is becoming, with every year that goes, harder for those to hold their own whose brain and soul are not behind their work.

The day has passed when a merely mechanical performance of duty achieved success. It is the brain behind the hand, and not the hand alone, which governs the world to-day. The old distinction between manual and mental labour is ceasing to exist. The purely manual worker is becoming a memory of the old days of muddling through. In the days that are coming, the days that are with us, he has no place. The ceaseless rivalry of commerce, the warfare of industry between nation and nation, leaves no room for purely manual labour. Men must be minds, and not machines. The brain in the chemical laboratories of Europe is undermining some of our oldest industries.

The Need for Choice and Training. There will be no room, in fifty years from now, for a SELF-EDUCATOR such as this. With the growth of a rational and national system, the education of the schools will cover the whole of life and not merely touch its fringe. But there is still a pressing need, unfortunately, for the education which tells in the world, the education which can be *applied*. How many boys, how many girls, set out every day on careers for which they are unsuited, or for which, if they be suited, they have not prepared? It is pitiful to reflect on the failure which might have been made success by a little training at the beginning.

The SELF-EDUCATOR has two great aims. It is, first, an earnest attempt to guide young people in the choice of a career and to equip them, or to help them to equip themselves, for the career they choose. It is at once a guide to study and a fountain of learning, a finger-post to industry and a school of practical training.

The Three Classes of Learning. No other single work covers the wide realm which the SELF-EDUCATOR makes its own. It gives, in its thousands of pages, a practical course of instruction in all branches of knowledge. It regards Culture and Commerce as one great whole, insisting on the essential unity of all things. It teaches all forms of knowledge and all their applications in Industry. Knowledge is the root of Business, and Business is Applied Knowledge.

If we divide knowledge into classes, all learning may be brought roughly into three divisions:

COMMERCIAL LEARNING.

The knowledge on which commerce is based—*i.e.* Mathematics, Geography, Grammar, etc.

SCIENTIFIC LEARNING.

Knowledge which may be acquired for its own sake or for humanity—*i.e.* Chemistry, Botany, etc.

PURE LEARNING.

Knowledge acquired for its own sake—*i.e.* Art, Literature, etc.

It is the applications of these branches of learning which make up the world of thought and action, and in the SELF-EDUCATOR we see Education in Action. Education in action, which is Industry, manifests itself in a thousand ways, and the SELF-EDUCATOR is a workshop as well as a school. It is a workshop in which we see going on all the manufactures and industries which make up the commerce of the world.

The Three Classes of Industry. Just as we divided education into three divisions, so Industry, Education in Action, divides itself into three main classes:

EXTRACTIVE.

Industries extracting the materials of nature for utilisation by the manufacturer—*i.e.* Electricity, Agriculture, Fisheries, Mining, etc.

CREATIVE.

Industries creating things out of raw materials—*i.e.* Arts and Crafts, Manufactures, Building, Engineering, etc.

EXECUTIVE.

Industries belonging to the management of affairs; the machinery of the working world—*i.e.* Railways, Ships, Banking, Shops, etc.

The SELF-EDUCATOR comprises all these great classes.

Commerce and Culture. But, though the EDUCATOR—believing that nothing is of any use in this world unless it can be applied—deals at great length with the education which tells in commerce, it is not to be understood that it is a book which merely helps to make money. If it is one of the purposes of the work to be a guide in the choice of a career, to make a successful man of business, efficient worker in any trade or calling, it is not less within its aim to make of him a capable citizen and a scholar. The SELF-EDUCATOR is designed to endow those who study it with a practical knowledge of the world in which we live, an intelligent appreciation of the principles upon which all life and nature are based, and an education which will enable them to be worthy members of society.

It is not an easy task to arrange an ordered plan of knowledge and industry which, while simple and clear, is also adaptable to the exigencies of serial publication. British commerce is a maze in which trades overlap and boundaries cross in bewildering confusion. A court of law once sat nine days, it is said, to decide what was a joiner's work and what was not, and it would require a millennium to devise a scheme of industry in which each task should hold its proper place and each man should perform his proper task. But it is believed that the SELF-EDUCATOR is at least a contribution to such a scheme of unity, and that those who study its methods will find any subject with ease. An exhaustive index, which will form a complete guide to the work, will be issued at the end, but it is desirable that the plan of the work should be thoroughly understood as it appears.

Arrangement of the Work. The work is arranged in twenty-nine groups, most of them divided into sub-sections. It is impossible, owing to difficulties incidental to any work appearing in serial form, to arrange the groups in a perfectly natural relation, and in some cases a merely arbitrary grouping has been unavoidable. But the important consideration in such a work as this—a plan which can be readily understood and followed—has been borne in mind from the beginning, and no elaborate explanation is necessary to explain the plan on which the SELF-EDUCATOR is devised.

The key to its twenty nine groups and their divisions makes it clear at a glance. It is not possible to follow the numerical order of the groups in serial publication, but the adoption of a simple method of sectional headings facilitates the task of the student following a definite course. Most of the headings in the first Part embrace a conspectus of the whole of the group which follows, and in all subsequent parts the headings indicate the group to which the particular article belongs. At the beginning of this Part is a key which shows the plan of the SELF-EDUCATOR at a glance.

Its Scope. No effort has been spared to make the work as exhaustive as such a work can be. A casual glance at any part of it will reveal the thoroughness with which the whole has been designed by the many minds which have concentrated in making it. If we take one subject only from the work, let us say Music, we find that the SELF-EDUCATOR embraces a treatment of the whole theory of music, a course of tuition in every modern instrument, technical instruction in the manufacture of musical instruments, and practical information and advice in the keeping of a music shop. The piano is followed, that is, from the factory to the shop—from the forest and the mine, indeed, to the orchestra and the drawing-room. So, too, with all the innumerable factors which make up the sum of our lives. Look around the room in which you sit, the street in which you walk, the railway platform on which you stand, the office in which you write, and the SELF-EDUCATOR reflects your vision. Into its scope come the beginnings and creation and uses of all the countless things which pass before our eyes wherever we turn.

A Modern Book. The student who wishes to be an artist will find in it a practical course of training; the man or woman who wishes to go through the galleries to see and understand the masterpieces of painting and sculpture will find this work a guide to the interpretation of art. The SELF-EDUCATOR is practical and intellectual too. It is neither a book for making capable craftsmen only nor a book for making scholars only: it is its province to do both, for in the view of life expressed by the SELF-EDUCATOR the two are one. There is no possibility in nature of an ignorant man being a good workman.

It need not be said that the SELF-EDUCATOR is modern on every page. It deals with many subjects on which no text-book exists in any European language. Its coloured plates contain examples of living things so recently discovered that science has not named them. In every department special emphasis is given to those phases of industry and commerce which are likely to develop in the future.

New Ideas. The cry of the politicians, and not of politicians only, is for new industries. It is not the least notable feature of the SELF-EDUCATOR that it points the way to new developments. Its curriculum has no convention. Everything contributing to the fullness of life comes into education as the SELF-EDUCATOR defines it. It contains within it the genesis of new industries and the development of old industries on new lines. A very careful investigation has been made into those phases of industry likely to develop largely in the future, and in this, as in all other ways, it is the effort of the SELF-EDUCATOR to be abreast of a strenuous age. It is a book of modern life, of modern thought, and of modern work, and its realm is as wide as the world

ARTHUR MEE

THE CHOICE OF A CAREER—AND AFTERWARD

By Sir Alfred Harmsworth, Bart.

NOWADAYS, the choosing of a career is not regarded so seriously as it was in the eighteenth, and well towards the end of the nineteenth, century. All who are interested in the welfare of our people will agree with me in describing this as an unfortunate feature of the social life of our time; for the result is becoming painfully evident in the number of young people one observes who are but indifferently equipped for their life-work. While general education has greatly advanced, it has not been so with the systematic study of individual tastes and qualifications in their application to the serious business of life.

The Prime Factor in the Choice. For the professions, it is true, there is to be noted a more thorough system of preliminary training than in the past. One has only to instance the modern doctor to illustrate this. Beyond all question, he or she—for no longer is it a profession of one sex—is better educated than the doctor has been at any period in the history of society. But I am persuaded that we are unable to take so desirable a view of the crafts, and I venture to doubt if sufficient attention is devoted to the training for and choice of a career in any of our great national trades. The practical abolition of the old system of apprenticeship is, in the judgment of many shrewd observers, a misfortune.

Naturally, the prime factor in the choice of any career should be personal taste, inclination. But, unhappily, we have only to look around us to realise how frequently the natural inclination is ignored. The world is full of round pegs in square holes. Who does not know that man who might have been a capable engineer, but is frittering his life away as an inferior clerk, doing work he detests? The engineer who might have been the organiser of a great warehouse; the lady typist who might have been a successful saleswoman, instead of an incompetent correspondent; the governess who would have made a clever typist,—who is not familiar with such as these, round pegs in square holes?

Late Beginnings. Occasionally one finds men who, in later life, have boldly broken away from servitude in occupations they had undertaken in error, or by force of circumstances, and have achieved success in their true vocations. Thus it is that instances of success in middle age and later life are by no means rare. The guiding brain of that great enterprise the Gordon Hotels was until middle age devoted to the law, and so, too, Lord Armstrong, the presiding genius of the famous Elswick Works, who followed the legal profession into manhood, although from his earliest years he had exhibited an extraordinary gift for mechanics. But, of course, there are occasions when it may be wise for a person not to follow the bent of natural inclination and to join loyally in maintaining a business that has perhaps been long identified with his family. Indeed, there is so much room in the world for people of average talent to apply themselves profitably that it might, for instance, be advisable in the case of a young man whose father was a prosperous local practitioner to follow in his father's footsteps. Heredity, undoubtedly, counts for something in the choice of a career, and often goes hand in hand with natural inclination. One thinks of families of successful statesmen, like the Cecils; of lawyers, like the Pollocks; and one remembers the two Pitts in statesmanship, the Stephensons in engineering. In other walks of life there are whole families of mechanics, carpenters, builders, and the like, known to most of us. In this connection, it is worthy of remark that one of the great difficulties which our American cousins have not been able to surmount in their efforts to wrest the cotton-spinning industry from us is the fact that they do not possess generations of trained workpeople such as we have in Lancashire.

England is not Overcrowded. Since there is no rule without its exceptions, one must not dare to dogmatise on this matter of heredity; but it is sufficiently clear that the volume of evidence in its behalf is so formidable that in the choice of a career it is a factor not to be ignored. There are times when it is well deliberately to disregard it—never to ignore it—but more often, by one of those curious traits of character which make the study of human beings so deeply interesting, sons revolt against the occupations of their fathers quite without reason; and too frequently this leads to emigration. Now, in my judgment, emigration is nearly always implied confession of failure. We must, however, make an exception in the case of agricultural workers, for whom there is always a fair field beyond the seas. But the result of considerable personal investigation into colonial conditions in many parts of the empire has persuaded me that the man who succeeds in the colonies might, with equal effort, fare as well at home. I do not believe that the United Kingdom is overcrowded with people. Belgium has no greater facilities for industry than are to be found in our own land, and her population of 7,000,000 people to 11,000 square miles brings Belgium not very far short of being twice as densely inhabited as the United Kingdom; yet it is true that the working classes of Belgium are among the most prosperous in Europe, in some respects being even better conditioned than our own working-classes.

Agriculture. Apart from party politics, which here would be entirely out of place, it may be said with the assurance of general agreement that our country is losing many of its industries, and for their disappearance various politicians have various theories and various remedies. As we are not gaining the newer industries, it follows that we must be marching backwards in some of the old. This is particularly

true of agriculture. And it is towards agriculture that I would direct the minds of those who contemplate emigration for the sake of an outdoor life. There is good reason for the agriculturist emigrating, for, although I have proved farming at home capable of being followed successfully, that is not on the system generally adopted at present. The young man who will make up his mind to learn to farm, and to begin modestly, may be assured of a healthy and not unprofitable occupation.

Agriculture is but one of the vast number of arts and crafts, vocations and avocations, that are dealt with in this all-embracing SELF-EDUCATOR; and I have been tempted to dwell upon it for the reasons I here give, and also because the practical and comprehensive manner in which it is treated in this work is typical of the earnestness with which the whole is being edited by my friend Mr. Arthur Mee, and written by a company of expert writers such as, I venture to submit, has not hitherto been gathered together for any one educational purpose. It is sincerely to be hoped that the reader in search of the best advice on the choice of a career or the best help to self-education will take up the SELF-EDUCATOR in the same earnest spirit as that in which it is being produced. For I fully believe that this work will not only instruct and become a permanent hand-book for daily reference in one's business, but that it will suggest to many readers avenues to usefulness of which they have not previously thought.

Industries of the Future. Nor should it be forgotten that there is always a rise or fall, a changing condition, in the trades of England. I may mention a case with which I am familiar: that of the industries connected with road life. In these industries there are now employed in France about half a million people more than were similarly occupied ten years ago. It is by no means unlikely that at least as large a number will yet be similarly employed in Great Britain, as the populations of the two countries are very nearly the same in extent. Throughout France hotels are being regarnished, fine new buildings are taking the places of old and out-of-date structures, while others are being reared where none before existed. In every town premises are being opened for the storage of road vehicles and depôts for the supply of fuel and other materials required in their propulsion. In a word, a vast new industry has sprung into being, and with its rise numerous other industries are affected, for the most part favourably. The making of self-propelled vehicles is alone a great industry in France to-day, although it is only in its infancy with us. Here, then, is a good example of the changing conditions to which I have referred, upon which the alert young mind should keep a watchful eye. This, one of the newest, as agriculture, the oldest of all occupations, will be found to be adequately treated in this work.

Touching again upon the professions, specialisation would seem to be the trend of the hour. Such ancient callings as the Law and Medicine are showing a marked tendency in this direction. One finds solicitors and barristers, for example, confining themselves chiefly to one of such specialised branches as the law affecting public companies, patents, licensing, divorce or copyright; while most of the leading medical men are known as specialists in the treatment of diseases affecting some particular part or organ of the human body—the chest, the throat, the ear and so forth. Even shopkeeping is developing on specialist lines. The careless general shop, with the pleasant, easy-going, but often unsatisfactory, relations between buyer and seller, is steadily giving way to the great specialist shops, having branches all over the country, each branch in the hands of an expert, the whole controlled by a master expert. I am not to be held as extolling the system as the best of all possible systems. I merely point to its existence and to the fact that it must be regarded watchfully by all seeking vocations.

A General Fault in choosing Trades. Then, again, a general fault in the choice of one's life-work is to follow blindly in the footsteps of some trade which, once profitable, may have ceased to be so; if not in imminent danger of extinction. Within the last two or three years, incredible though it may sound to those familiar with the unhappy conditions of the trade, I have met people learning wood-engraving; an occupation practically—and I regret to think so—dead. They had been articled to some wood-engraver by their parents, who had not taken the trouble to find out that this class of engraving was being superseded, has long been superseded, by the many cheaper and quicker processes of photo-etching.

Thus far, it will be remarked, I have referred mainly to the occupations in which the earning of money is esteemed of prime importance; though that may be allied to genuine pleasure in the work. Of course, there are others. Those who approach music, painting, sculpture, literature, mainly with the idea of accumulating money thereby are not likely to succeed in their ambition. But it may be said of these pursuits, that, followed professionally, they are affording to their professors increasing returns in the material rewards of life; while not less to-day than in times past do they minister to the highest and best that is in mankind. One is often asked, Who buys the modern pictures, and what becomes of the musicians? Well, there are more painters and musicians to-day in England than at any other time, and I do not find, on looking at the official reports of bankruptcies, that the arts are more dangerous than commercial occupations to those who engage in them.

Opportunities for Women. Perhaps the most remarkable feature of latter-day employment is the great increase in the occupations for women. This is a development that may be good, or may be ill; but the tendency is increasing beyond question, and it is the business of the SELF-EDUCATOR to reckon with it. A glance through this work will show

an abundance of occupations for young women, many of which are by no means overcrowded. Speaking personally, as the director of a considerable business, I would like to make complaint of the inefficiency of the majority of young women who attempt to enter business life from shorthand and typewriting schools. We find that not more than 5 per cent. are of any use until they have received a great deal of training in the office; and this would not be the case if they had earnestly endeavoured to qualify themselves for the work during the year or two they had, presumably, devoted to attendance at schools. It is to be feared that many of them take to these pursuits somewhat lightly and without a due estimate of their responsibilities.

Having chosen an occupation in life, one has next to consider a no less difficult question: the means of obtaining success. In some measure good fortune is possible to anyone who is blessed with health. For although all cannot be equally prosperous in their affairs, everyone can make some kind of mark. But not by travelling the old roads.

The Education that makes Money. Education all the world over—I do not say the best education, but the kind of education that makes money—is increasing. As a result, brains work more rapidly, though perhaps not so thoroughly as they did in the past. In every direction we observe that men of active minds are breaking away from tradition and making fortunes by their boldness; in many cases by actual reversal of the policy of their forefathers.

It is not, in my opinion—and I base my statement on knowledge of successful men in many lands—the young man who seeks an appointment in an old-fashioned business, and settles down doggedly to the humdrum, plodding work of doing his duty and observing precedent, who attains, even in the long run, to competency, far less to fortune. There are thousands of men in this and in every land who are hoping to make fortunes that way, and who never will. It is the man who goes into the shop, and, out of his own resourcefulness, his open and nimble mind, shows his employer how to sell new kinds of goods in new kinds of ways, that eventually becomes strong enough to enforce his demands to a share of that shop or some other shop. The new thing and the new way; or the old thing in a new way—either means success if there is concentration behind.

Concentration of Purpose. But this young man must be well in body all the time, so that his mind may be free to devote itself to that prime secret of success—CONCENTRATION. Fortunes come to audacious gamblers now and then, and such rare but disastrous examples do, I know, disturb the minds of young men; for every venture in life has, it must be admitted, at least some slight element of gambling. But, after all, it is *concentration of purpose* that is the backbone of all success in the world, be it that of the poet or the pork packer. He who has cultivated the habit of concentration looks round every proposition so thoroughly that he may be said to have, so far as is humanly possible, eliminated therefrom every element of risk that a man can suppress. The gambler is not only beset by risks, but seeks them; and the fate of the deliberate gambler in business is usually as dismal as that of the gambler in "play."

Finally, after concentration has brought about the initial success, optimism of temperament is necessary. It does much to carry with it those who are around one, associated in a common enterprise, and it brings with it that leadership which is so essential to success in every walk of life. When Ferdinand de Lesseps began to talk of cutting the Suez Canal no one believed him, and, as a matter of fact, he was, as he himself confessed, on the wrong track at first. But gradually his forceful optimism persuaded individual after individual, and then nation after nation, that the thing could and should be done, and it was done, despite the belief of great engineers that the task was impossible. His career is an ideal one to study from the point of view of those who seek success. He may be said to have done an old thing in a new way—for had not the Ptolemies done it 2,000 years before?—and he had concentrated his whole existence on it.

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true of agriculture. And it is towards agriculture *that I would direct the minds of those who contemplate emigration for the sake of an outdoor life. There is good reason for the agriculturist emigrating, for, although I have proved farming at home capable of being followed successfully, that is not on the system generally adopted at present.* The young man who will make up his mind to learn to farm, and to begin modestly, may be assured of a healthy and not unprofitable occupation.

Agriculture is but one of the vast number of arts and crafts, vocations and avocations, that are dealt with in this all-embracing SELF-EDUCATOR; and I have been tempted to dwell upon it for the reasons I here give, and also because the practical and comprehensive manner in which it is treated in this work is typical of the earnestness with which the whole is being edited by my friend Mr. Arthur Mee, and written by a company of expert writers such as, I venture to submit, has not hitherto been gathered together for any one educational purpose. It is sincerely to be hoped that the reader in search of the best advice on the choice of a career or the best help to self-education will take up the SELF-EDUCATOR in the same earnest spirit as that in which it is being produced. For I fully believe that this work will not only instruct and become a permanent hand-book for daily reference in one's business, but that it will suggest to many readers avenues to usefulness of which they have not previously thought.

Industries of the Future. Nor should it be forgotten that there is always a rise or fall, a changing condition, in the trades of England. I may mention a case with which I am familiar: that of the industries connected with road life. In these industries there are now employed in France about half a million people more than were similarly occupied ten years ago. It is by no means unlikely that at least as large a number will yet be similarly employed in Great Britain, as the populations of the two countries are very nearly the same in extent. Throughout France hotels are being regarnished, fine new buildings are taking the places of old and out-of-date structures, while others are being reared where none before existed. In every town premises are being opened for the storage of road vehicles and depôts for the supply of fuel and other materials required in their propulsion. In a word, a vast new industry has sprung into being, and with its rise numerous other industries are affected, for the most part favourably. The making of self-propelled vehicles is alone a great industry in France to-day, although it is only in its infancy with us. Here, then, is a good example of the changing conditions to which I have referred, upon which the alert young mind should keep a watchful eye. This, one of the newest, as agriculture, the oldest of all occupations, will be found to be adequately treated in this work.

Touching again upon the professions, specialisation would seem to be the trend of the hour. Such ancient callings as the Law and Medicine are showing a marked tendency in this direction. One finds solicitors and barristers, for example, confining themselves chiefly to one of such specialised branches as the law affecting public companies, patents, licensing, divorce or copyright; while most of the leading medical men are known as specialists in the treatment of diseases affecting some particular part or organ of the human body—the chest, the throat, the ear and so forth. Even shopkeeping is developing on specialist lines. The careless general shop, with the pleasant, easy-going, but often unsatisfactory, relations between buyer and seller, is steadily giving way to the great specialist shops, having branches all over the country, each branch in the hands of an expert, the whole controlled by a master expert. I am not to be held as extolling the system as the best of all possible systems. I merely point to its existence and to the fact that it must be regarded watchfully by all seeking vocations.

A General Fault in choosing Trades. Then, again, a general fault in the choice of one's life-work is to follow blindly in the footsteps of some trade which, once profitable, may have ceased to be so; if not in imminent danger of extinction. Within the last two or three years, incredible though it may sound to those familiar with the unhappy conditions of the trade, I have met people learning wood-engraving; an occupation practically—and I regret to think so—dead. They had been articled to some wood-engraver by their parents, who had not taken the trouble to find out that this class of engraving was being superseded, has long been superseded, by the many cheaper and quicker processes of photo-etching.

Thus far, it will be remarked, I have referred mainly to the occupations in which the earning of money is esteemed of prime importance; though that may be allied to genuine pleasure in the work. Of course, there are others. Those who approach music, painting, sculpture, literature, mainly with the idea of accumulating money thereby are not likely to succeed in their ambition. But it may be said of these pursuits, that, followed professionally, they are affording to their professors increasing returns in the material rewards of life; while not less to-day than in times past do they minister to the highest and best that is in mankind. One is often asked, Who buys the modern pictures, and what becomes of the musicians? Well, there are more painters and musicians to-day in England than at any other time, and I do not find, on looking at the official reports of bankruptcies, that the arts are more dangerous than commercial occupations to those who engage in them.

Opportunities for Women. Perhaps the most remarkable feature of latter-day employment is the great increase in the occupations for women. This is a development that may be good, or may be ill; but the tendency is increasing beyond question, and it is the business of the SELF-EDUCATOR to reckon with it. A glance through this work will show

an abundance of occupations for young women, many of which are by no means overcrowded. Speaking personally, as the director of a considerable business, I would like to make complaint of the inefficiency of the majority of young women who attempt to enter business life from shorthand and typewriting schools. We find that not more than 5 per cent. are of any use until they have received a great deal of training in the office; and this would not be the case if they had earnestly endeavoured to qualify themselves for the work during the year or two they had, presumably, devoted to attendance at schools. It is to be feared that many of them take to these pursuits somewhat lightly and without a due estimate of their responsibilities.

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THE UNITY OF THINGS

THE CENTRAL WONDER OF THE UNIVERSE

By Dr. W. H. Fitchett, Author of "How England Saved Europe"

THAT the world—the visible system of things about us—is a kingdom of mystery, an enchanted realm, we know; and it is striking to observe how steadily, as the area of knowledge widens, the sense of the mystery in the very structure of the universe deepens. It is always true, of course, that the wider the illuminated disc, the greater is the curve of encompassing darkness. But this is not all. The wonder deepens in the illuminated area itself. The light does not scatter the mystery; it makes it only the more profound.

And it is curious to note how what may be called the centre of mystery is shifting. It lies to-day rather in the inconceivably little than in the immeasurably great. Science is teaching us that the infinitesimal is almost more wonderful than the infinite. Yesterday the material vastness of the universe burdened the imagination, and threatened to kill faith. The frontiers of the physical universe were being pushed ever back. The heavens grew higher, the depths more profound. New hosts of stars were sweeping continually into view. What a difference betwixt the night-sky that our simple-minded fathers, with unassisted eyes, beheld, and the same sky seen, through, say, the gigantic equatorial telescope of the Lick Observatory! And the wonders seen even by the astronomer's eye through the great telescope are less, by almost measureless degrees, than the wonders registered by a sensitised plate attached to the eyepiece of the telescope.

The Infinitely Little. But to-day, we repeat, the centre of wonder in the physical universe has shifted. The startled imagination lingers not so much over the infinitely great, as over the infinitely little. What a flame of mystic and almost unquenchable fire burns, for example, as we now know, in a microscopic speck of radium! The flame of Arcturus seems, if not commonplace, yet intelligible, when put beside it. It is not some vast aggregate of matter—a planet hung in the depths of space—which seems to us most wonderful. It is the molecule! Beneath the "open sesame" whispered by science, that which was till yesterday supposed to be the ultimate form of matter—the atom—becomes transparent. Its boundaries are passed—and what strange kingdoms stand revealed to knowledge! Here is a system of electrons—inconceivably minute points of electric energy—moving in orbits like the stars, and with the speed of light. The constellations that burn in the midnight skies—Alcyone, and its sister planets—are less wonderful than the starry constellations, packed within the curve of every atom. A system of rushing stars hidden in a molecule! Here is food for wonder of which our fathers never dreamed.

Yet, to the brooding and instructed imagination, the centre of wonder in the system of things shifts once more. Not things, but the relation of things, is that which, when even faintly realised, startles the mind most. Only slowly, in broken gleams of light easily lost, do we come to see that all forces, things, lives, are linked together by subtle and far-reaching ties, so that the whole system, of which we form part, is a unit. The universe is not a cluster of unrelated facts, but an organism. Not a chaos, but an ordered kingdom.

The Identity of Matter. Sometimes we catch, or think we catch, a glimpse of the solidarity of the universe when we are reminded of the identity of widely separated forms of matter; or of the unity which lies behind a thousand varying kinds of force. Let a tiny point of hydrogen flame from a smoker's match be taken, and a gleam of radiance from, say, the belt of Saturn: what can express the interval, measured in terms of space, which separates these two tiny points of fire! Yet, when tested by the spectroscope, they are found to be identical. Here is the revelation of a strange identity of structure, which holds good across the utmost bounds of the universe. And there are hints of identities equally wonderful in every realm.

All forms of force, for example, as science analyses them, run back into one force. What is the pull of gravitation, the leap of electricity, the swift-running vibration of the light, but disguises—or expressions—of that mysterious ether which, according to our latest science, promises to explain everything, but about which we know nothing.

The Time-relation of Things. Yet it is not the identity in structure of things parted by the utmost vastness of space, or the unity—hidden beneath all diversities of working—which links together all the forms of force, that most impresses the imagination. It is, we repeat, the subtle, infinitely close, yet infinitely complex, relations betwixt things which makes the wonder of the universe. Each fact stands related to every other fact; to all that was, or is, or is to be. What may be called, for example, the time-relation of things is, when realised, nothing less than amazing. The child in a board school sees his teacher stand beside the blackboard with a bit of chalk in his hand. What is that bit of chalk to the child, or even to the teacher himself? Merely a convenient substance for making white lines on a blackboard. But, as a matter of fact, that bit of chalk is an ancient cemetery, in which lie buried creatures that lived, and played their part in the system of things, whole milleniums ago! In the yet warm seas of the slowly-cooling planet

floated myriads of infusoria, with power to secrete from the sea in which they floated a sheltering film of lime. As these tiny myriads died, the microscopic facing of lime they wore—or their limy skeletons—sank through the warm unmoving waters to the sea bottom. In process of ages this grew to a white slime; some convulsion of the earth's structure lifted up the ancient sea bed, and the soft white slime became a chalk cliff. And the bit of chalk in the teacher's fingers represents the whole process! What ages, what revolutions, what a measureless geology that little bit of white earth hides in its atoms. It is, in a sense, a perished eternity which the teacher holds in his fingers.

Perished Eternities. The bit of coal, again, that lies in the grate represents, like the bit of chalk, a life that existed, and energies that were in operation, at a period which lies uncounted ages distant. The gas in the burner, the fire in the grate, are but heat of summers that glowed, the flame of suns that shone in an antiquity so far behind us that the imagination cannot even guess its date. Each form of matter that the eyes see or the fingers touch to-day is, in this way, the index of a perished eternity.

All this may, perhaps, seem fanciful. It may stir the imagination, but has no practical significance. What is of supreme significance is the present relation of things to each other; the close, subtle, uncomprehended wedlock which links all forces, all forms of life, into strangest unity. Behind each apparently isolated fact are relations which make it a part of every other fact. Here, again, the illustrations lie close at hand, hidden in familiar things.

A bud on a tree in springtime—a little cluster of swelling leaves, packed in its tight sheath—is the most commonplace of objects. But what brings it there? What bids the close-packed leaves swell? The mysterious forces of spring, it will be answered; the energies of the brown earth, the kiss of the falling rain, the heat of the quickening sun. These are behind the bud, and explain it. But this "explanation" is superficial, and itself needs to be explained. The spring bud, a wiser answer declares, is the index of stellar changes; its explanation runs up into the movements of the planets. That tiny, close-packed bundle of swelling leaves tells that the earth has swung into a new angle to the sun. And if it is asked why the earth has turned one of its aspects thus towards the sun—how far back the explanation must go! The spring bud is only the last link in a chain of movements which runs back not merely to the roof of the heavens, but to the dawn of all worlds. Here is a planetary movement translated into vegetable terms, and set before our senses. We see only the bud; and, if called upon to explain it, think only of that abstraction, "the spring." But the wheeling planets, and the far-off forces that move the planets, are in the tiny curve of that solitary and tender bud.

The Colour of the Rose. What explains the colour that burns on the leaf of a flower—the white in the curve of a lily, the purple in the tiny cup of a violet? The answer, of course, is that the colour comes from the sun. But let all that is included in that answer be realised. The sun is 93,000,000 miles distant; the colour which delights us in the flower—the crimson in the heart of the rose, the scarlet of the poppy—eight minutes ago was actually in the sun, all those immeasurable leagues distant! How did it reach the flower and become visible there? The running waves of light from that far-off sun smites the leaf of the flower. By some process of vital chemistry, which baffles our wisest science to guess, the leaf disintegrates the ray. It selects and absorbs some of the colour elements, and reflects others. The miracle goes on while we gaze, and under our very eyes; it is a living and continual process. What we see is only the last link in a chain of wonders. Nay, it is not the last link; for "every end," to quote Emerson, "is a beginning. Every ultimate fact is only the first of a new series." The disintegrated light on the leaf of a flower sends its vibration through the optic nerve of the eye that looks upon it to the brain behind the eye; and then, by another mystery before which science is dumb, to the soul behind the brain it brings the sensation of colour. The blue in the forget-me-not, the crimson in the rose, the white in the lily are but links in a chain of relations betwixt our consciousness and the sun 93,000,000 miles distant. The tiny flower, it may be said, interprets the ultimate elements of light to our consciousness.

The Pebble on the Beach. A pebble, to take another homely illustration, lies on the beach, and nothing could well be more inert and commonplace. But how came it there? Why does it lie on that exact spot and no other? This, it will be at once said, was determined by the force and direction of the wave that flung it there. But what was behind that wave, and determined its direction and energy? The pressure of the wind; and this, in turn, had for its cause some unknown changes of heat or cold, stretching over unknown kingdoms of space, and determined by forces which run up to the crown of the heavens and back to the beginning of the worlds. In a sense, it would have required a totally different history of the physical universe to have cast that pebble a few inches higher!

It is possible to look at a luminous arc of electric light and see in it only a curve of calcined vegetable fibre, through which an electric battery is forcing a current. The resistance to the current explains the light. But what is there behind the battery; and whence comes that strange force that pours into the arc? Made visible in that flame, again, is a force running to the uttermost bounds of space, and which itself may be but a disguise of that ether which is the ultimate stuff of which the universe is made.

The Inter-relation of Facts. Each familiar fact within the sweep of our sense, in brief, is the index of a whole mysterious history; a process that stretches back to the

first syllable of unrecorded time. Things are symbols; they are but counters in nature's mighty currency. Each movement, each pulse of energy, each form of matter, is but the last link in a chain which runs back into mystery and into eternity.

But there is a deeper wonder than even that which lies in what we have called the time-relation of things—the history that lies behind things: it is the mystic, uncomprehended, yet quick and vital inter-relations of things at the present moment, which, when realised, makes the wonder of the universe. No fact is isolated. No event is solitary. No force works alone. No life exists but as part of all other lives. The nerve system of the human body, which links all its organs into consciousness, is only a symbol of the close-knitted relationship which binds the whole visible system of things into unity. An astronomer watching the disc of the sun sees a pulse of more vivid light sweep across part of its surface. It is an electric storm, kindling the flame of the sun over a certain area to a new intensity. And in every observatory on earth, at the same moment of time, the electrical *instruments record what is happening! These vibrate in rhythm to that pulse of energy in the far-off sun.*

The Opening Flower. *And across all the depths of the space, the greatest things in* the universe call to the smallest; the bud, as we have seen, to the planet; the flame of colour in the flower to the flame of light in the sun. The bud swells as the planet wheels, and because the planet wheels.

What is the relation betwixt a grain of wind-driven sand in a city street and the earth, or the whole system to which the earth belongs? Does not that grain of matter attract every other grain in terms of known law? If destroyed, its withdrawal, it is mathematically certain, would affect the gravity of the earth; it would change its course and speed through space. The planet, it may be said, needs the atom, and would itself be different if the atom were destroyed. So profoundly do even what we call insensate things affect each other; so closely and vitally do they belong to each other! The old doctrine of the conservation of energy is insufficient. The new teaching of science is the identity of all forms of energy.

The Energies of the World. In one pregnant and striking passage, Emerson says "the entire system of things is represented in every particle. There is somewhat that resembles the ebb and flow of the sea, day and night, man and woman, in a single needle of a pine." But this is inadequate. The needle of the pine not merely belongs to the system of things; all its energies pulsate within it. The rhythm of forces in the sea tides, the procession of day and night, is felt in, and shared by, every fibre of the tiny pine needle.

Tennyson was not a scientist, but he had a poet's vision into the meaning of science, and a poet's sympathy with its interpretation of the universe, and he has compressed a true scientific philosophy into half a dozen familiar lines:

"Flower in the crannied wall,
I pluck you out of the crannies,
I hold you here, root and all, in my hand,
Little flower—but *if* I could understand
What you are, root and all, and all in all,
I should know what God and man is."

Solidarity of the Race. Only an accidental flower; planted by no gardener's care, but sprung from some wind-blown seed; yet think what mystic relations radiate from that tiny, unnoticed blossom! Relations with the winds which bore it to the crevice in which it lies; to the rains that watered it, the brown earth that fed it, and the far-off sun from whose untwisted light it takes its colour. And what is true of the flower in the crannied wall is true of every other form of life, or pulse of energy, or shape of matter found in the whole web of things. The universe is a vital unit, and all its parts belong to each other, affect each other, are part of each other.

But if all this is true of the great network of forces, and changes and things, which make up *the visible universe, it must certainly be true—and true in an even higher and closer sense—of the human race, which is the crown of things; the race which has for the material universe the function that the thinking brain has for the* human body. The solidarity of the race—the fashion in which we belong to each other, affect each other, are responsible for each other—is but faintly expressed by the kinship which subsists betwixt material things. *In* the profoundest sense, the race is a living organism. We realise this only faintly as yet. The "solidarity of the race" is looked upon as a figure of speech, a poet's fancy. But the consciousness of that solidarity is growing. It will yet capture the reason of mankind and become imperative to its conscience. And when it has done this it will re-shape society and mould all our politics to a new pattern.

The Living Organism of Society. Our politics to-day are, in many respects, a denial of the great assertion of scripture that "God has made of one blood all nations to dwell on the face of the earth." Our social laws are in too many points in conflict with the very conception of human brotherhood. Hence the disorder in the social system, the strife in the relation of nations. But science in its own terms, and by its own logic, is repeating the teaching of the Bible. It is slowly making visible the solidarity of the physical universe; and the unity of the race is but the highest expression of that solidarity. Vainly do seas divide nations, and diversities of speech or differences of colour—most fatal of all separating forces!—part one tiny fragment of the human race from another. The race, the Bible teaches, and science affirms, is a unit. And, under the laws that govern life, every part belongs to every other part; gains by its health, droops with its sickness, is made glad by its happiness, suffers with its pain.

The whole political history of the race may be described as a parable setting forth in concrete forms the wreck and misery caused by the forgetfulness of its own unity by the human race. One nation has dreamed it could grow great by the destruction of other nations. A class has imagined it could prosper at the cost of other classes. And history, with its record of wars and revolutions, of empires destroyed, and kingdoms wrecked and classes cast down, shows how nature—or rather that Moral Government which is above the universe and uses nature as its tool—has whipped all such selfishness.

Indian Wheat and Kent Marriages. All this is true to-day; it applies to the society of which we are a part. Some examples of the vital relations which link men together lie on the very surface. A heavy wheat crop in India or Siberia means a higher marriage rate in Kent or Staffordshire. The failure of the cotton crop in Carolina means that the looms in Bradford and Leeds are idle. A "corner" in the Chicago Stock Exchange is translated into empty pockets, pawned furniture, and hungry little children in Lancashire. The suspicions and alarms betwixt the nations of the world yield another illustration—in sepia, so to speak—of the fashion in which we belong to each other. If one great Power invents a new rifle and spends millions in arming its soldiers with it, every other great Power must strain its wits to invent a still better rifle, and must tax its subjects to the very quick to pay for the luxury. For every rivet driven into the sides of a German or French battleship, English hammers must drive two rivets into the sides of British battleships. The nations cannot separate themselves from each other, any more than a man, by taking hold of his feet, can lift himself off the earth. The effort to isolate does not really break any bonds. It only inflames all bonds.

The Linking of all Lives. And it is not merely that nation touches nation. Individual is linked to individual; the poet to the clown, the millionaire to the pauper, the sons and daughters of nobles to the ragged child in the slums. We cannot separate our fortunes, or arrest the influences by which we touch each other. Society is a ship in which we are all passengers. What imperils the ship, poisons its atmosphere, relaxes its discipline, casts a shadow of danger on every life the ship carries. Blake, in one tremendous couplet, writes a profound truth:

> "A starved dog at the city's gate
> Foretells the ruin of the state."

The swift instinctive vision of the poet read that deep but as yet unrecognised law that want unfed is the business not only of the poor wretch who feels it, but of the whole society in which the hungry man stands. It points to some social disorder; some false relation betwixt men; some breach of wise and Divine law. The strength of a nation, its wealth, its happiness, are but the sum total of the strength and wealth and happiness of the units which compose it. So a brain left untaught, a conscience unquickened, a faculty undeveloped, a want unfed, represents a loss which makes the state, and every member of the state, poorer.

Unity of the Moral Realm. But this law runs far beyond the boundaries of commerce or of politics. In the moral realm no one will deny the relations which knit men together, and the forces by which they act on each other. In that high kingdom we are bound to each other by ties more subtle than anything matter knows, and surer because of their very intangibility. The shadow of a leaf lying on the glittering blade of a razor will permanently mark it. What can be lighter than a shadow, what harder than polished steel? But the touch of even a shadow marks the steel. And character in each of us is a force that, for good or evil, is perpetually touching all other characters. In the great realm of moral forces, certainly, "no man lives to himself." A fearless, upright soul reinforces goodness in every soul it touches. An evil man radiates wickedness. He taints the general conscience. He makes goodness harder, and evil easier, for everyone about him.

These, of course, are platitudes; but they do not exhaust—they do not even adequately describe—the area of our relations. The profound teaching of Christ, which is yet to transfigure the world and recreate society, is that who touches for good or ill his brother touches Him! Our acts towards each other reverberate to the very throne and person of God. Service to each other is service to God. Neglect of each other is neglect of God. The denial of another's need is a refusal that runs up to the crown of the universe, and sends its echoes forward to the Judgment Seat itself. As Whittier sings:

> "Who hates, hates Thee, who loves becomes
> Therein to Thee allied.
> All sweet accords of hearts and homes
> In Thee are multiplied."

Thinking Universally. We are exhorted by many voices to-day to "think imperially"; and no one will deny the loftiness and wisdom of that appeal. Thought, for us, if we would not fail, must be as wide as facts. We must recognise all ties, accept all duties, feel all the relationships which run out from us, and use all the resources which belong to us. We must "think imperially" in science, or we misread the universe; in politics, or we shall wreck the empire; in commerce, or we shall drift into bankruptcy; in morals, or we shall leave half our duties forgotten and see half our life spoiled.

But though the phrase, "Think imperially," is large, it is scarcely large enough. We must think, so to speak, in cosmic terms! We must consent to feel ourselves part of the whole system of things, touching all lives and all forces, and touched by all. We must think of the universe, not in fragments, but—as its Maker planned it, and Himself thinks of it—as a unit, an ordered kingdom knitted together through all its forms and to its utmost boundaries by relationships so close that they cannot be escaped; yet so subtle that they can hardly be realised.

W. H. FITCHETT.

GEOGRAPHY

A STUDY OF THE EARTH IN ITS PHYSICAL AND POLITICAL ASPECTS

WITH A SPECIAL TREATMENT OF

HUMAN AND COMMERCIAL GEOGRAPHY, NATURAL PRODUCTS AND THEIR DISTRIBUTION.

THE EARTH'S SURFACE: AIR, LAND, WATER

Rain. Wind. Temperature. Climate. Land Forms. Mountains. Rivers. Valleys Glaciers. Volcanoes. Destructive and Conservative Agencies. Distribution of Land Continents and Islands

THE SEA

Oceans of the World. Ocean Depths. Tides. Currents. Coasts.

THE LIVING WORLD

The Zones of Plant Life. The Realms of Animal Life. Man. Races of Mankind Government. Religion. Material Civilisation. Population and Politics of Europe

COMMERCIAL GEOGRAPHY

Man's Utilisation of the World's Products. His Destructive and Creative Methods Utilisation of Raw Materials in Art and Manufacture. Land and Sea Products Manufactures. Transport by Land and Sea.

BY

Dr. A. J. HERBERTSON, Lecturer in Geography, Curator of School of Geography at Oxford University; Fellow of the Royal Geographical Society.

THE RELATION BETWEEN THE EARTH AND HUMAN LIFE

By Dr Herbertson

Of the many definitions of Geography, which in itself means only a description of the earth, perhaps the most useful for us is that it is the study which deals with the relation between the earth and life, and particularly human life.

We study this relation for two reasons. The first is because we must. We are wholly dependent on the earth on which we live. There is no other source from which we can obtain food, shelter, clothing, and the other needs of our material life. This is disguised from many of us because we inherit the fruit of the labours of the pioneers, the men who have found out in the course of centuries the best way of using certain of the earth's resources.

Man and the Earth. But the complex life, which in great cities seems to move of itself, depends at bottom on very simple causes. Something, plant or animal, grows somewhere, or is dug out of the earth somewhere; it has to be procured and transported, and modified by human ingenuity, and finally exchanged for some other necessary or luxury of life. All over the world men are striving to make two blades of grass grow where one grew before, to irrigate the desert, to till the waste, to introduce new and superior kinds of plants and animals, so that the world may be better and better able to support its teeming children. Yet all that is being done is but a fraction of what there is to do. New lands are no longer to be sought, yet new trades are waiting for their discoverer, and new sources of wealth to enrich him. We study geography first to learn what the world has to offer to man, how he has used it in the past and present, and how he might use it more profitably still. Till we know a great deal about the world we live in we are, as it were, working in the dark. Knowledge is power.

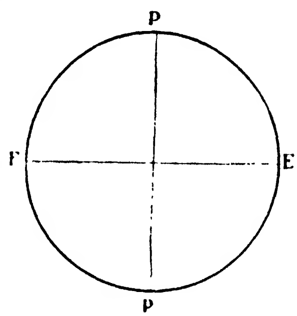
The Busy Working World. The second reason, out of many we might give, is even better. The more we know of the world the more we are filled with respect and admiration for our fellow men, and the more we desire to be of use to them. We see the Eskimo fashioning out the most skilful weapons from the bones of slain animals, building boats of their hides, lighting and warming himself by burning their fat, supporting himself, and bringing up brave and hardy children. The Indian woman in the western desert, where neither wood nor clay is to be had, patiently gathers dry stringy desert plants, plaiting out of them the baskets, water-bottles, and cooking-pots that she needs. The Chinaman works night and day in his flooded rice fields, knee deep in water, stabbed with rheumatic pains, bent, weary, glad to creep out of the burning sun under the shade of the mulberry trees his thrifty hands have planted along the raised wall of his rice field. The hill peoples of the Himalayan valleys, terracing their hill-sides, ceaselessly carry up soil, basket by basket, when the foaming river below leaves a little uncovered; they bring water by this laborious means and by that, and finally they brighten a tiny patch of the bare hillside with a fruit tree or two, and a little square of golden barley. Who would not be filled with admiration for a race that shows such noble courage and ingenuity under the hardest conditions of life? We cannot think

of men in this way without ourselves becoming kinder and braver, and better fitted for our own battle in life. History and human life take on a new dignity and a new meaning.

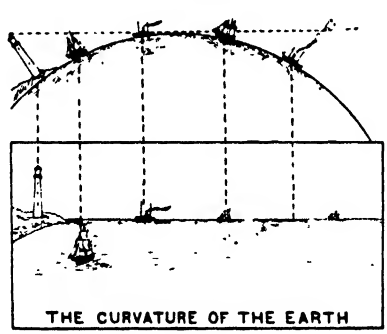
The Source of Light and Life. Where, then, are we to begin our study of a world which has developed such wonderful qualities in its sons? With that on which all depends—the relation of our speck of a planet to the great sun round which it moves [4]. If the sun's heat and light were withdrawn but for an hour life, as we know it, would cease to be. The laws which keep the earth in its invisible path round the sun, which bring back in due season day and night, seed time and harvest, are those on which the whole life of the world is built up. On the variations in the heat the earth receives from the sun depends again the whole system of winds and rain; on these the life of plants: on the life of plants the life of animals and man. Every geographer must be in his heart something of a sun-worshipper, and must sympathise with those who have, in various times and places, worshipped it as divine. He will, at least, never forget that by it we live and move, and have our being.

The Planet Earth. The earth on which we live is one of many *planets* surrounding the sun, which is the source of all their light and heat. In shape it approximates closely to a *sphere*, and is generally represented as such. A few people still believe that it is flat. Many considerations, however, show that this is impossible.

1. EARTH'S SHADOW ON MOON.



2. POLES AND EQUATOR.
P. Pole, EE. Equator; PP Axis of Rotation.



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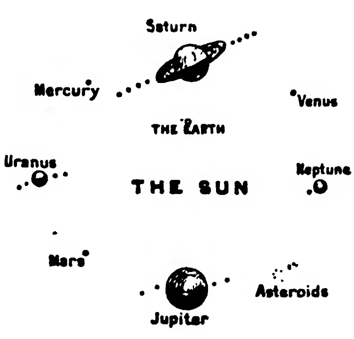


THE SUN & PLANETS

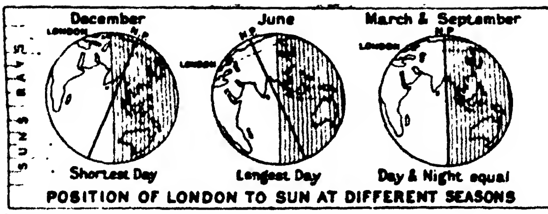
4. SHOWING THEIR COMPARATIVE SIZE.

Perhaps the most convincing is the uniform dip of the horizon at sea, or on a plain [3]. At sea the masts of a ship come into sight while the hull is still hidden by the curve of the earth, so that the ship seems to be sailing up-hill. For the same reason the hull of a receding ship disappears first, and the top of the masts last. On a voyage to our colonies of South Africa and Australia, new stars, which have been hidden by the curved surface of the earth, come into sight, and the familiar constellations disappear over the horizon, or rim of the earth. During an eclipse of the moon the shadow of the earth is outlined on the moon's disc, and it is circular [1.] Finally, the weight of objects is almost uniform at the same height above sea-level at all parts of the earth's surface. This could hardly be the case on a flat earth. Weight results from the pull exercised by the force or attraction known as gravity, or gravitation. If it remains the same it must be because the distance from the centre of attraction remains approximately the same. A figure in which every point on its surface is equally distant from a given centre is a sphere. This implies that the earth is spherical. [For fuller treatment of the subject, see PHYSICS.]

The Earth's Rotation. The earth is not at rest. It revolves round the sun once in 365¼ days, and rotates on its own axis once in twenty-four hours [7]. These two movements give two fixed measures of time, the day and the year, which have been in universal use since the dawn of history. Both movements are of profound importance in fitting the earth to be the home of living creatures. Their nature and consequences must be clearly understood, or our geographical ideas will always be superficial and confused.

Day and Night. The most dramatic of the consequences of *rotation*, the unvarying sequence of day and night, is so impressive that these phenomena are noticed and named by even the lowest races, who often invent grotesque legends to account for what they cannot otherwise explain. What really happens is that the earth is ceaselessly turning in one direction, into the sunlight and out of it. In common language we say that the sun rises and sets. In reality it is always shining, but a particular

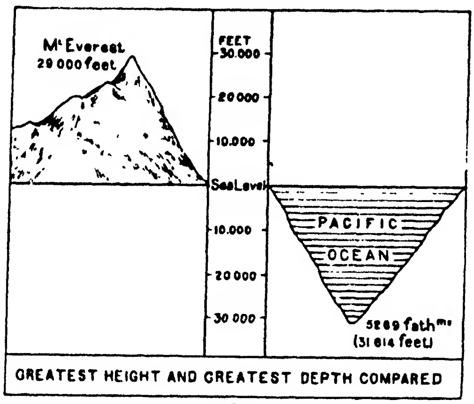
place on the earth's surface has moved into or out of its light. The direction in which the sun comes into sight is called east, the direction in which it disappears, west. The earth, therefore, is rotating from west to east. As it turns, point after point catches sight of the rising sun, and begins its day, while on the opposite side point after point loses sight of the setting sun, and begins its night.



5. SHOWING THE VARYING LENGTHS OF DAY AND NIGHT. [Shaded portion indicates night.]

The first result of rotation, therefore, is that all parts of the world have a share of the sun's light and heat. If the earth did not rotate, one side would always face the sun, and would have perpetual day, and one side would always be turned away, and would have perpetual cold and darkness. Rotation prevents a great part of the earth's surface from being uninhabitable.

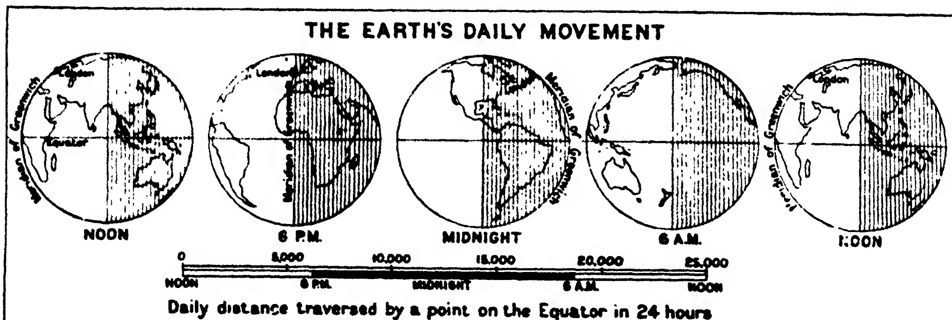
Our Daily Journey. We are so familiar with these facts that we seldom realise how vast a journey we make every day of our lives without being conscious of it. Its actual length depends on the position of our home on the earth. This may be clearer if we think of spinning a top so that it rotates in the same manner as the earth. If we draw on the top a series of parallel circles it will at once be seen that these diminish in circumference from the largest, which is round the middle of the top where it bulges out most, to the extremities. Clearly, a point on the greatest or middle circle makes a longer journey during one rotation than a point on the second circle, and must therefore move quicker. Similarly, a point on the second circle travels further and moves quicker than a point on the third, and so on till we come to the top and bottom, where the circles are reduced to two dead points, for which there is no journey at all, and which are therefore at rest. On the spinning or rotating globe these stationary points, where the earth's movement is reduced to zero, are called the poles. The line joining them is called the axis of rotation. Exactly halfway between the poles we get the greatest circumference, which is represented on our globes or models of the earth by a line called the equator. If the earth were cut through the equator it would be divided into two half spheres, or *hemispheres*, which would be exactly equal. It is hardly necessary to caution the student that the equator is an imaginary line, which is marked on our globes for convenience of measurement [2].



6.

The Earth's Dimensions. Knowing the meaning of the terms pole and equator, we can define the shape of the earth more exactly and estimate its size.

If the earth were a perfect sphere the polar diameter would be exactly equal to the equatorial diameter. This is not the case. The equatorial diameter measures 7,927 miles, the polar diameter only 7,900 miles. We find, too, that objects are slightly heavier at the poles than the equator. This shows that points on the earth's surface at the poles are very slightly nearer to the centre of gravity than points on

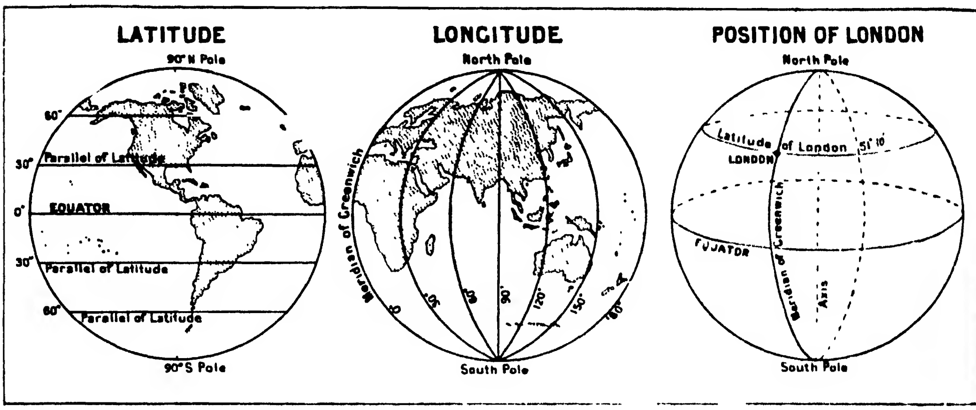


7. [Shaded portion indicates night.]

the surface at the equator, or, in other words, that the earth is very slightly flattened at the poles. Such a figure is called an *oblate spheroid*. The earth's surface is very irregular, pitted, in fact, like the skin of an orange. The highest mountain is about 5½ miles high (29,000 ft.), and the greatest ocean depth is rather more (31,000 ft.). The difference between the two is equal to 12 miles nearly, or half the difference between the polar and equatorial diameters [6].

the horizon, the shadow of a man or a tree points north.*

To fix the position of a place we require, however, more than these general ideas of direction. They are not sufficiently precise. London is south of Edinburgh, but it is north of Paris. For practical purposes the measurements known as *latitude* and *longitude* are employed. Latitude measures distance north or south of the equator. Longitude measures distance east and west of a



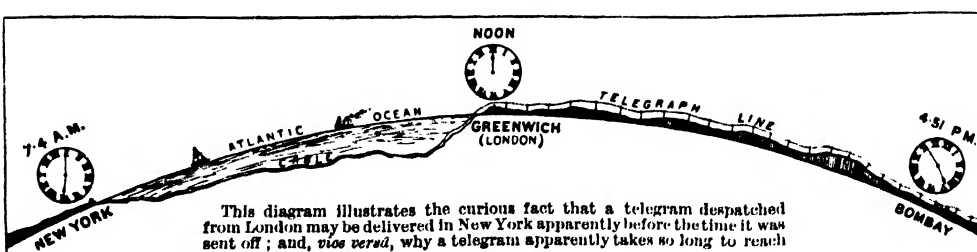
8. EXPLANATION OF LATITUDE AND LONGITUDE, SHOWING HOW THE POSITION OF A PLACE IS DETERMINED ON THE EARTH.

Such irregularities are allowed for in estimating the dimensions of the earth, but no estimate is absolutely correct. The circumference of the earth at the equator is about 25,000 miles. The area of its surface is estimated at 197,000,000 square miles.

Direction and Position. Our first ideas of direction come from the rotation of the earth. The direction in which the sun rises we call east, the direction in which it sets, west. If we stand with the east on our right hand and the west on

line joining the poles and cutting the equator at a known point [8].

Latitude. The circumference of a circle contains 360 degrees, written 360°. The actual value of a degree varies, but it is always $\frac{1}{360}$ of the whole circumference. A semicircle contains 180°; a quarter circle, or quadrant, contains 90°. The distance between pole and equator is a quadrant, or 90°. On a globe we see circles drawn parallel to the equator. These are called parallels of latitude, and they measure the dis-



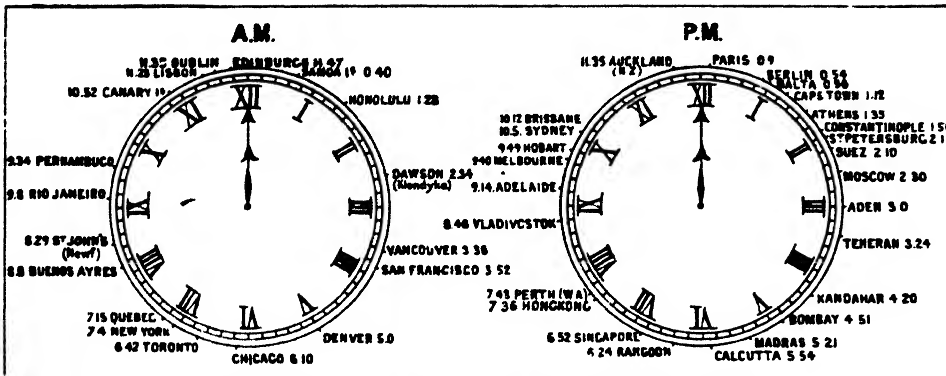
This diagram illustrates the curious fact that a telegram despatched from London may be delivered in New York apparently before the time it was sent off; and, *vice versâ*, why a telegram apparently takes so long to reach Bombay.

9. SIMULTANEOUS TIME AT LONDON, NEW YORK, AND BOMBAY.

our left the direction towards which we face is called north, and the direction to which our back is turned, south. The corresponding poles are the *North Pole* and the *South Pole*. The hemisphere containing the North Pole is the Northern Hemisphere; that containing the South Pole, the Southern Hemisphere. In the northern hemisphere at midday, when the sun is highest above

tance from the equator in degrees. They are numbered from 0° to 90°, the equator being 0°,

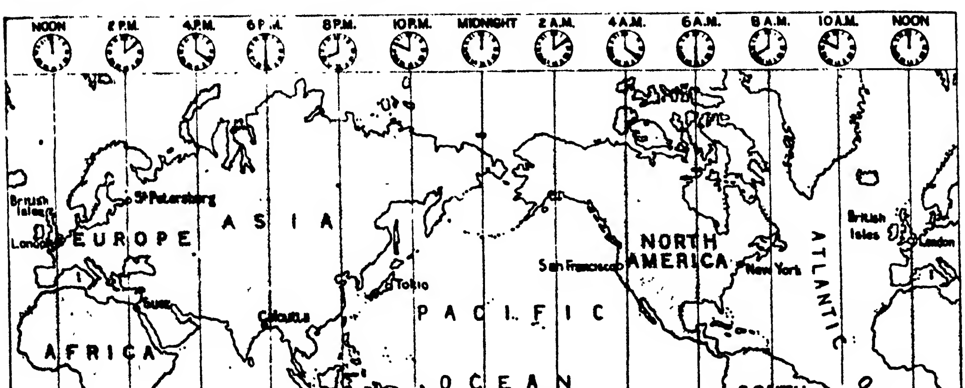
* As we often want to know direction when the sun is not shining, the mariner's compass is used for practical purposes. In its construction use is made of the fact that an iron needle is deflected to the north by the magnetism of the earth [See PHYSICS]. Such a needle is fixed on an indicator, on which thirty-two directions, or points of the compass, are marked.



10 COMPARATIVE TIME WHEN NOON AT GREENWICH

the poles 90°. Whether north or south latitude must also be stated. 90° does not tell us which pole, but 90° N. identifies the North Pole, and 90° S. the South Pole. All points with the same latitude—that is, on the same parallel—are equally distant from the equator. On globes the parallels of latitude are usually drawn for every 5° or 10°, but on large scale maps they may be drawn for every 1°. Distances less than a degree are expressed in minutes, written ′; and seconds, written ″. 1° = 60′ = 60 × 60″ = 3600″.

Longitude. If we know the latitude of a place we do indeed know on which parallel of latitude it lies, but not its position on this parallel. To decide which of all the points on the parallel in question is the one we want we must also know the longitude. In reckoning longitude, or distance east and west, we have nothing corresponding to the equator as a starting-point. Any place may be selected, but Greenwich, which has a famous observatory, is generally taken. A line joining the poles and passing through Greenwich is called the meridian of Greenwich, or the prime meridian, or sometimes the zero meridian. Every point on the prime meridian has the longitude 0°. The point at which it cuts the equator has latitude 0°, longitude 0°—written lat. 0°, long. 0°. From the prime meridian the others are measured and numbered east and west. As there are 360° in a circle, the meridians will run from 0° to 180° E., and from 0° to 180° W., the meridians 180° E. and 180° W. being identical, and passing through the middle of the Pacific Ocean. Now we can locate any point of which we know both the latitude and the longitude. It is the point where the meridian indicated by the longitude cuts the parallel indicated by the latitude.



11. STANDARD TIME ALL OVER THE WORLD.

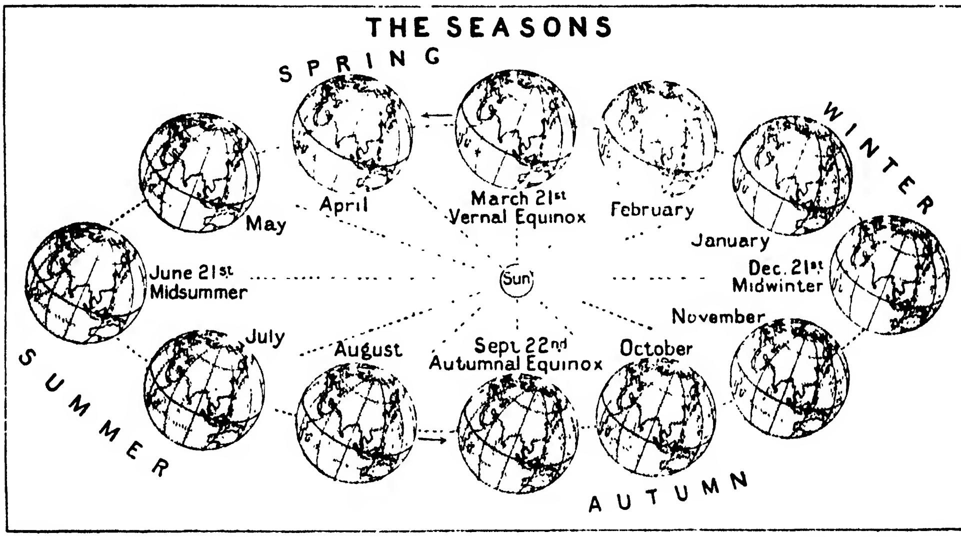
It may be noticed that, while a degree of latitude has always the same value, a degree of longitude decreases from the equator to the poles, to which all the meridians converge. If an orange is skinned the arrangement of its sections illustrates this convergence very prettily.

Measurements of Time. The rotation of the earth enables us to measure time as well as space. The starting-point of our reckoning is noon, the moment when the sun is highest above the horizon. All places on the same meridian—which means midday—have noon, or high sun, at the same moment [11]. The earth rotates through 360° in twenty-four hours—that is, through 15° in an hour. Consequently, when it is noon at Greenwich it is 1 p.m. on the meridian of 15° E. and 11 a.m. on the meridian of 15° W. On the meridian of 30° E. it is 2 p.m., when it is only 10 a.m. on the meridian of 30° W. Similarly it is 3 p.m. on the meridian of 45° E. and 9 a.m. on the meridian of 45° W. On the meridian of 180° it is midnight [10]. Is it midnight to-day, or is it midnight yesterday? Questions of this kind are settled by international agreement. The custom is for a ship sailing eastwards across the Pacific to reckon two consecutive days of the same name as it crosses the meridian of 180°. As the meridian falls in mid-ocean no inconvenience is caused. A ship sailing west drops out a day. Similar agreements are made for changing the hour. Thus, if a traveller from England goes to Belgium his watch will correspond with the Belgian clocks, for these are regulated by Greenwich time. If, however, he goes on to the German frontier the clocks there show mid-European time, by which his watch will be an hour slow. The time thus shown by clocks is called *standard time.* It generally varies more or less from true local or sun time, but it is very convenient to have uniformity of usage [9].

Revolution and its Consequences. The earth revolves round the sun once in a year. The path it traces out, its *orbit*, is an *ellipse*, which brings it in December to a distance of 91½ million miles from the sun, and removes it in June to 94½ million miles. The plane in which this orbit lies is not that of the equator, but the two are inclined at an angle of 23½°. In other words, the axis of rotation is not upright, as in the spinning-top, but tilted. As the earth's axis is always tilted in the same direction, each hemisphere is tilted towards the sun alternately in the course of one revolution. A single glance at the diagram makes this clear [12].

Each hemisphere, therefore, alternately receives a maximum amount of light and heat, and experiences the phenomena known as the seasons. If the axis of the rotating earth were vertical, the rays of the sun would always fall vertically on the equator, which would probably be too hot for human habitation, while most of the other regions which are now densely peopled would certainly be too cold. The inclination of the axis, and the yearly revolution, complete the work of rotation and render nearly the whole of the earth fit for habitation.

The Seasons. Let us now consider carefully the relation of earth and sun throughout a year [5]. On March 21st the sun is vertically overhead at the equator, and the earth presents, as it were, its rim towards it. The sun's rays fall equally towards both poles, which they just reach. Day and night are therefore equal all over the world. This is the *spring* or *vernal equinox*. The earth is now moving into that part of its orbit in which the northern hemisphere is tilted towards the sun. The sun rises daily higher above the horizon in the northern hemisphere, and the days grow longer and warmer. This is the spring of the latitudes north of 23½° N. lat.



12. THE REVOLUTION OF THE EARTH ROUND THE SUN IN EVERY MONTH OF THE YEAR.

To be continued

HISTORY

THE STORY OF THE WORLD FROM THE BEGINNING UNTIL NOW

OPENING WITH

THE FIRST DEFINITE THING WE KNOW, AS REVEALED BY RECENT RESEARCH IN BABYLON

AND INTRODUCING

The Dawn of History	The Birth of Europe	The Rise of Napoleon
Empires of the East	England	French Revolution
The Rise of Greece	The New World	Reorganisation of Europe
The Coming of Rome	Democracy	The Revolutions of 1848

WITH

A SURVEY OF THE NATIONS AND PEOPLES OF THE WORLD OF OUR OWN TIMES

BY

JUSTIN McCARTHY, Author of "A History of Our Own Times"

BABYLON, THE FIRST PAGE OF DEFINITE HISTORY

By Justin McCarthy

THE dawn of history sometimes appears to generations which have left it long behind as if it were but the dusk of history, with utter darkness growing on. We seem to lose all possibility of bringing ourselves back into association with those periods now submerged in darkness. Then suddenly comes some enterprise of exploration and research, which appears to open for us the very tombs of the past and gives us light by which to study their contents.

The Dawn of History. For some generations the genius of research has been illuminating the earliest records, and in our own time has been making itself more and more manifest. The city of Babylon, the capital of the great Babylonian Empire, has thus been recovered for us from that apparently mythological region to which, for many centuries, it had been consigned. Explorers have discovered buried cities, and the research of qualified scientific and historic scholars has found in the shattered walls and broken pillars of these buried capitals ample and unquestionable records of that place at that period of the world's history. When the ruler of a people is at pains to record on monuments of stone or tablets of metal an account of the events which have happened during his time, we may take it for granted that he did not defy public opinion, even such public opinion as there was in his day, with regard to his authorized description of the events which he saw and had helped to create. Any discoveries made afterwards by historical research have generally tended to confirm the accuracy of these monumental records.

Babylon Re-created. Thus the modern world has been able to re-create the famous city of Babylon, which had been for so long shrouded in legend. Pliny, the Roman historian, born some twenty years after the opening of our Christian era, declared that in his time the site of Babylon was only a desolate wilderness. Early in the eighteenth century European explorers gifted with a scientific and historical intelligence set themselves to study this desolate wilderness, and from that time down to our own days explorations of the same kind and for the same object have been going on. Mr. Rich and Sir R. Ker Porter were among the first who conducted these researches, and more lately Sir Austen Henry Layard, Sir H. Rawlinson, and M. Botta rendered most valuable service to the world by their studies of the rediscovered monuments. Babylon was in its great days the most superb city then found in the world. Its Hanging Gardens appear to have been constructed, each of them, in the form of an amphitheatre, in terraces, one rising above another, and ascended by steps, the whole structure supported by huge arches raised on arches.

Most of the inscriptions carved on the relics which the modern explorers succeeded in discovering were in the cuneiform character. These were translated by Sir Henry Rawlinson and others, and helped to throw much light on the lost history of Babylonia. Sir H. Rawlinson delivered many lectures on the subject at different times in London, and he gave to the British Museum many relics of the greatest historical and archæological value. The Rev. Professor A. H. Sayce delivered lectures on Babylonian literature, and Mr. Robinson Souttar, in his "Short History of Ancient Peoples," published only two years ago, has thrown much light on the history of Babylonia.

The People of Babylon. The region of which Babylon city was the capital lies northwest of the Persian Gulf, bounded on the north by Assyria, and on the west by Arabia. It is a broad flat country, watered by the Euphrates and the Tigris. At one time the soil was rich and well-watered, and had a liberal growth of trees and plants. Babylonia gave evidences of what must be called civilization before any other land except Egypt alone, and Abraham, the parent of the Twelve Tribes of Israel, was by birth a Babylonian. The Babylonians as a people were mainly occupied in agriculture, and they were advanced enough in the principles of civilization to construct a great system of canals, all of

which were used for the purposes of irrigation, while some of them were large enough to be sailed upon by boats, and thus made available for the business of commerce. The people of Babylon were in those distant days entirely devoted to the work of peace. Their subsequent history shows us indeed that, like most other populations who began with peace, they soon drifted into war and efforts at conquest.

A Code of Laws. Mr. Souttar's volume is enriched by an introduction from Professor Sayce, who tells us that, owing to recent research, "We know now that Egypt and Babylonia and Assyria enjoyed a culture and civilization of high order, long centuries before Herodotus or even Homer, and that the elements of Greek culture itself were derived from the East." He tells us, too, that owing to modern researches "in Babylonia, a code of laws had come to light eight centuries older than that of Moses." This code of laws "embodied the decisions of the royal judges in the various cases which for unnumbered generations had been brought before them." So lately as 1902, Professor Sayce tells us that a copy of this code, now deposited in the Louvre, Paris, was found by M. de Morgan "among the ruins of Susa, to which it had been carried as a trophy by an Elamite invader of Babylonia," and that this code "testifies to the existence of a highly-organized and long-established society and to respect for property and law." Again, we are told that "notice is taken even of the operations of a surgeon and a veterinary; if they are successful, the amount of the fee is fixed; if they result in death or blindness, the unskilful practitioner has to submit to punishment."

Babylonian Buildings. We learn that splendid palaces were built, lavishly ornamented with frescoed walls and floors, while the ordinary houses were built with stories and windows like those of a modern day. There were two or three systems of handwriting in use, and it is only in quite recent years that we have come to know of the mere existence of those methods of expression at an age so utterly remote from ours. Modern discovery has, indeed, made it certain that Greece itself was about the same time as Babylonia enjoying a degree of culture and civilization which passed away afterwards and left a blank of long endurance, so that, in fact, the culture which we now regard as identified with the Greece of classic days was but a renaissance in the most distinct sense. "Ancient history is," Professor Sayce tells us, "in truth, being re made in our days, and from time to time it is needful to take stock of the knowledge of it which we have thus far acquired, and to place it before the world."

Babylonia, at the period when it comes into the dawn of history, was apparently inhabited by a mixed race, of the most part Semitic—that is to say, the race claiming to descend from Shem, a Hebrew race in fact. The very earliest of the population, however, seemed to have been Accadian and the earliest cities were of Accadian creation. The antiquity of some of these cities is well established by the style of the cuneiform writing found on their monuments, which evidently belongs to the earliest and rudest days of that writing's development, and also by the nature of the language itself, which is not akin to the Semitic, or Hebrew, but bears greater affinity to the Persian. The earlier inhabitants of the region were soon absorbed in the stronger Semitic race, and the Semitic language became the usual medium of conversation, although the original tongue was for long after kept up as a study by Babylonian scholars.

The Babylonians did not rise to anything like a high level in the character of their religious belief. They were for the most part idolatrous and polytheistic. Astrology and even astronomy were much studied in Babylonia. Their divinities were the Lord of Heaven, the Lord of the Sea, and the Lord of the World, and in lower orders of deities came the gods of the sun and the moon and the air, and several orders of minor deities, some of these only recognised in certain localities. The Babylonian populations had their own sacred books, their collections of hymns, psalms, and even incantations, and different forms of service to be used on the days marked out for the worship of the different deities. They had fast days, and a Sabbath day, which was in itself a strictly religious institution. Among their many legends describing the creation of the world and the deluge was one which set forth the story of the Tower of Babel.

Babylonian Books. The Babylonians were a reading people, and formed many libraries. Their books did not, however, resemble in form or in material the volumes which occupy the shelves of a modern library. Babylonian books were, indeed, sometimes written on papyrus, but, for the most part, they were constructed of clay tablets, on which the writer inscribed his ideas with a letter stylus or pen, while the clay was yet plastic, and then put them for a while to dry and grow hard in the sun. There are not so many material evidences to be found concerning the early history of Babylonia as there are for the early history of Assyria, and this is to be ascribed in great measure to the fact that the Babylonians had but a limited quantity of stone at their disposal in their soft and earthy country-sides, and that they therefore made use of the more readily perishable sun-dried clay for the registration of their history and for their every-day purposes. We know quite enough to make us certain that the Babylonians were a reading people, so far as reading could be accomplished in their time. They were students of astronomy in the practical sense, and they even went so far as to prepare astronomical observations. They divided the firmament into constellations, and to them we owe the introduction of the signs of the Zodiac. The week was divided by them into seven days, and the civilised world has followed their example in this plan for the division of the year into weeks, while the names still retained, which call certain of the days after the sun and the moon, are adopted from the Babylonian method.

The Early History of Babylonia. Our knowledge of Babylonia's early history tells us, as most histories do, of the struggles between rival populations and rulers. Then came a period when Assyria, at first a Babylonian colony, succeeded in conquering Babylonia itself, and then followed the reigns of a number of rulers whose names and whose conjectural history it is not necessary to deal with in this course. Under one of these sovereigns Babylonia became released from the suzerainty of Assyria, and united upper and lower Babylonia under one rule, and then Babylon became the capital of the united people, and remained so for fifteen centuries. One of the greatest sovereigns who ruled over the united Babylonian Empire was Nebuchadnezzar, or, as some historians call him, Nebuchadrezzar. Under his power Babylon became more and more a great city. He reigned for 42 years, and may be said not merely to have rebuilt Babylon, but to have restored almost every temple throughout the country and to have raised many new buildings of the same order.

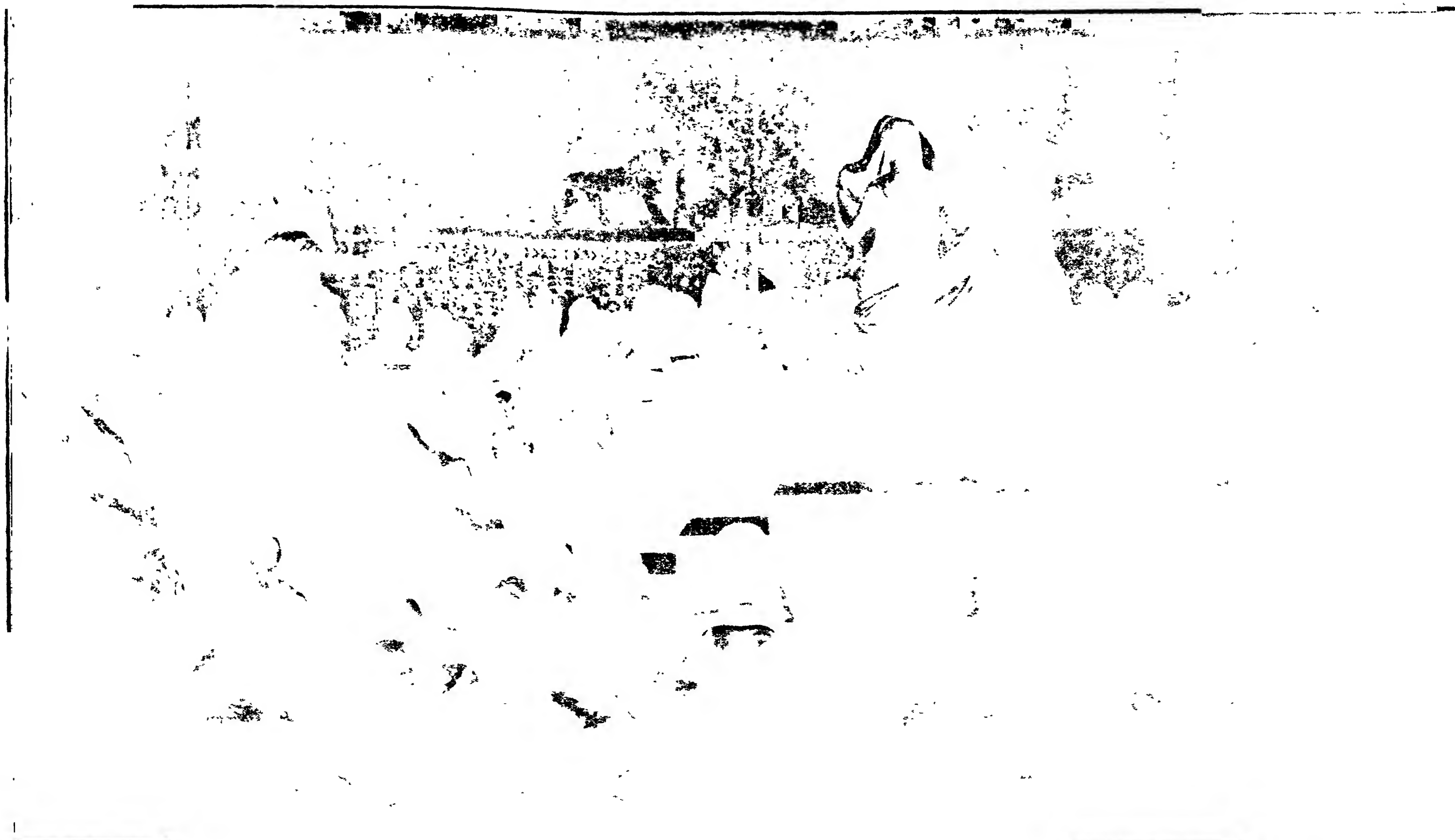
Daniel. We are told that every mound opened by explorers in modern days has contained tablets inscribed with Nebuchadnezzar's name. He was an invader, like most other monarchs of his time, and he afterwards besieged and captured Jerusalem, and later still did his best to devote the city to destruction, and removed many of the Jewish inhabitants to Chaldea. One of those thus removed was the prophet Daniel. For an account of the closing period of Nebuchadnezzar's life we have to look mainly to the records bequeathed by Daniel. The country had then a time of peace, but Nebuchadnezzar himself was for some seven years the victim of a dangerous form of insanity. He recovered at last from this particular affliction, and seems to have come back to his subjects a wiser and a much better man. It would appear that during the short remainder of his life he was able to make himself much admired and trusted by his people, but he did not live long. He died some 560 years before our Christian era, and is said to have been then more than eighty years of age.

A Man Born to be King. Nebuchadnezzar was unquestionably a man of great and varied ability, a man of genius, in fact. He would have been famous as a soldier and a general had he been only a soldier and a general, but he was also an architect of the highest capacity, endowed with much artistic imagination, a thoroughly practical engineer, and a man who might well be described as born to be king. But he was, according to all records, one of the most despotic even among despots. His cruelties to those he had conquered seem to have been sometimes outrageous and wanton, even for that era, when conquest and cruelty generally went together. But he behaved with remarkable kindness to the prophet Daniel, and for a time he actually set up Daniel as something like an object of worship. It is evident, indeed, that he had during his strange and varied career many generous impulses, and had even gleams of an internal light, which now and then seemed to be leading him to a higher form of worship than that which prevailed at his court and throughout his people. During his reign Babylon became a great city covering some 144 square miles of ground, and from its walls arose some 250 towers, while it had 60 gates of bronze picturesquely moulded. The river Euphrates had its course through the middle of the city, where it was crossed by a magnificent bridge of stone, and the bridge had noble embankments, and on each side a superb imperial palace. The care of the ruler extended also to the other parts of his realm. He built many temples in other cities as well as in Babylon, he constructed canals, and also great reservoirs for the important work of irrigation.

The Empire of Nebuchadnezzar. When Nebuchadnezzar's career closed, his Imperial sway had spread to a vast extent, but like other imperial systems constructed after the same fashion, it had to depend altogether on military ambition and military strength and skill to hold it together. That is, indeed, the peculiarity of all monarchies which take under their control several different nationalities subjugated by force of arms. There is no common impulse of loyalty, and when the grip of power relaxes the captives begin to disperse. When Nebuchadnezzar died there was no one qualified to take the place he had maintained, and the empire he had formed began to fall asunder.

The son of Nebuchadnezzar, Evil-Merodach, succeeded to the throne of Babylonia. He seems to have been a man of liberal and merciful spirit, and was much in advance of his age with regard to the toleration of religious creeds and practices differing from his own. It is even said that the indulgence that he showed to the Hebrew religion created alarm and anger among the idol-worshippers of his day, and led to the conspiracy which accomplished his death. That conspiracy was headed by his own brother-in-law, who, after the assassination of the ruler, succeeded to the throne. Evil-Merodach had reigned for only some two years; his successor held for over four years the position which he had won by his crime, and he was followed by the last sovereign of that dynasty, whose reign came to an end within less than twelve months.

The Beginning of the End. Another sovereign, not of the same house but related to it, was ruler of the state for some seventeen years, but during his time Babylonia began to show many evidences of declining power and of relaxing cohesion. The desire of the new sovereign appears to have been to make the city of Babylon not only the centre, but even the sole stronghold of religious and political activity and display. He thus aroused the jealousy and the hostility of the provincial populations. In fact, the whole of Babylonia turned in revolt against him because of the neglect which he had shown for his duties as a sovereign to all the populations outside that of the capital.



19 BABYLON AT THE HEIGHT OF ITS PROSPERITY: "THE BABYLONIAN MARRIAGE MARKET."

From the painting by EDWIN LONG, R.A.

The Rise of New States. In the meantime new states and new combinations of states were forming in the East, and soon began to threaten the now somewhat weakening Babylonia. The Babylonian frontiers had for near neighbours four distinct nationalities. These were the Manda population, a barbaric race sprung from the Scythian invaders; the Medes, who had settled northwards towards the Caspian; the Elamites, living in the eastern mountain ranges, and the Persians, settled on the shores of the Persian Gulf. The Manda had a sovereign ruler, Astyages, of whom history was to hear much, and the King of Elam was Cyrus, of whom history was to hear much more. For a time the sovereign of Babylon and Cyrus would appear to have been on terms of friendly agreement, and both alike looked upon Astyages as a dangerous rival for empire. According to inscriptions found on some tablets dug up in modern days, the ruler of Babylon believed that he had been in a dream inspired by one of his gods to attack the Manda people, and, guided by this dream, he formed an alliance with Cyrus. This alliance led to a war against Astyages, in which Astyages was completely defeated and his dominions were annexed by Cyrus.

The Conquests of Cyrus. *The spirit of conquest carried Cyrus much farther. He became master of Persia, and was received there all the more readily because he claimed descent from the Persian royal family.* After his victory over Astyages, a victory in the results *of which, as in the accomplishment of which, Cyrus assumed the greater part,* he was able to unite under his sovereignty the Elamites, the Persians, the Medes and the Manda. *It soon became evident to the Babylonian sovereign* Nabonidos that, although Cyrus and he had begun in alliance, such a condition of friendship was not likely to last long. Babylonia was already beginning to feel that the alliance with Cyrus was not much to be depended on. She was about to form an alliance with Crœsus, the sovereign of the Lydians, but Cyrus, understanding probably how things were going, invaded Lydia before the ruler of Babylon could intervene. The result of the struggle between Cyrus and the Lydian monarch seemed uncertain in the first battle, but Cyrus, with the instinct of conquest, continued his movements so rapidly and so effectively that he completely defeated his opponent and captured his capital. **Cyrus now had stretched his rule from the Caspian Sea to the Mediterranean, and he then began at once an invasion of Babylonia on the north. His first attempt was not successful, as the fortifications of Babylon were powerful, but, as we have already said, there was much disaffection among the populations under the rule of Nabonidos, many of whom were actually foreigners forced into Babylonia by some of its former rulers. These foreign populations were willing to support the intervention of any new invader, and the army of Cyrus won a complete victory over the Babylonian King. Thereupon the second city in Babylonia, Sippara, surrendered to the invader without putting him to the trouble of accomplishing its capture by force of arms.**

New Ruler of Babylonia. This event proved to be practically decisive of the struggle, for Babylon soon after made its surrender to the conqueror. Nabonidos was made a prisoner, and kept in chains for some months, after which he died, or, in all probability, was actually put to death in prison. Cyrus was now the recognised ruler of the country, for the son of Nabonidos, Belshazzar, had fallen in battle, or been put to death. Cyrus had evidently much of the genius of a ruler, and he did his best to make himself acceptable to the Babylonians. He reversed the policy which had been making Babylon the seat of all authority, and of all recognised position, by restoring the provincial cities to their full share of influence, and by inviting exiled Babylonians to return to their natural home. He was *also systematically tolerant to differences of religious faith, and he was friendly and liberal towards the Hebrews. Babylonia finally* became a part of the Persian Empire, and its history thus becomes mingled with that of Greece, as we shall see in another part of this course. In later days the city of Babylon passed out of living existence, until "only mounds of rubbish remained to mark the site it had once occupied" in such splendour and power. The Babylon of which we now know so much has, therefore, been restored to the world's history by the energy, the intellect, and the keen scrutiny of modern explorers, archæologists, and scholars, most, if not all of them, coming from seats of European education. It was in its great days a centre of power, of intellect, and of art; it is now but a memory and a fame.

To be continued

AGRICULTURE. BEEKEEPING. GARDENING

A THOROUGH TRAINING IN THE GENERAL CONDUCT OF A FARM

COMPRISING

THE PRACTICE OF AGRICULTURE UNDER MODERN CONDITIONS AND IN ALL ITS BRANCHES

Soils	Manures	Hay-making	Farm Machinery
Seeds	Live Stock	Wheat Growing	Farm Buildings
Crops	Harvesting	Farming Abroad	Farm Servants

DAIRY AND POULTRY FARMING

Cows. Milk. Cream. Butter. Cheese. Municipal Dairying. Poultry for Pleasure and Profit

BEEKEEPING

How to Keep Bees. How to Obtain a Good Return of Honey. Commercial Side of Beekeeping

GARDENING

Home and Commercial Gardening. How to make the Most of a Minimum of Land
Fruits and Vegetables. Management of Glasshouses and Nurseries. In Business as a Gardener

AND EMBRACING THE

APPLICATION OF SCIENTIFIC METHOD IN FARMING AT HOME AND ABROAD

BY

Professor JAMES LONG, formerly of the Royal Agricultural College; Founder of the British Dairy Institute; Medallist of the Royal Danish Agricultural Society; Commissioner for the British, United States, Canadian, and New Zealand Governments.

J. B. LAMB, Member of the Council of British Beekeepers' Association; and other experts

THE PRACTICAL TRAINING OF THE YOUNG FARMER

By Professor James Long

AGRICULTURE is the term which is applied to the cultivation of the soil and the crops which grow upon it.

Its successful practice depends upon knowledge acquired by study, experience, and industry. In the long past no special form of instruction was provided for young men and women who were intended for a life on the land. The son learnt his business from the father and the men whom he employed, and by going to plough on the smaller holdings as soon as he became able, and taking his place as a labourer with a prospect of succession as tenant or owner. And so with the daughter, who learned from her mother the practice of milking, butter and cheesemaking, and poultry-rearing, in addition to those varied household arts—baking, preserving, curing, and the like—which present her as such an agreeable contrast with her successors of to-day.

The Products of the Soil. The education of our ancestors in relation to our great industry was, indeed, empirical. Science had not placed her finger upon the weak points which restrained the most progressive and far-seeing farmers, and it was not until it had extracted from Nature some of her most valued secrets that old theories and practices were exploded, and man was shown how beautifully and perfectly the Creator has provided for the production, through the medium of the soil, of all that man requires for his material comfort and support.

While we depend upon the soil for all we need, whether it be food or clothing, for the construction of our homes, for the maintenance of our warmth in winter and protection against the heat of the summer's sun, we also depend upon the rain and the atmosphere. Whatever may have been the origin of animals and plants, we know that to-day the former depend upon the latter for their maintenance, and that in a large measure the latter depend upon the former. As between the two kingdoms Nature works in a cycle; the plant feeds the animal, which returns to the soil as manure what it does not utilise, this embracing a large proportion of those plant-feeding materials which have been extracted from it, so that its fertility is in large part maintained. Where crops are grown and entirely removed—where, in fact, no such return is made, the soil gradually but surely loses fertility, and in our modern system of high culture, where the feeding of the soil is confined solely to a return of the dung which its crops have produced, it is still, if less rapidly, impoverished, and really successful cropping becomes impossible. It is where the soil receives more than is removed from it—whether through manure produced by animals, whose rations have been enriched by foods, such as cakes and grain imported on to the farm, or by the addition of what are known as chemical or artificial manures—that progress is made, and the crops are increased in weight and value.

"Intensive Culture." It is practically this system of feeding the soil, combined with thorough working, which is known as "inten-

sive culture." What foods it is most desirable to purchase or to grow for the successful feeding of stock, and what manures it is most profitable to employ for the sustenance of particular crops, it is for the farmer to ascertain, and, happily, at the commencement of the twentieth century he is able to learn gratuitously and from many sources precisely how to act in each case. His ancestors possessed few of the advantages which are placed to-day at his disposal. Many of the most valued concentrated foods, and those we chiefly import, were unknown, whereas the chemical fertiliser, which plays such a masterly part in the agricultural system of all enlightened countries, like the principles upon which its employment is founded, was but a dream, and that only in the case of a handful of prescient and enlightened men.

sugar, both of which, like the oil of plants which in the grain of linseed forms 37 per cent. of its total weight, are rich in carbon. Plants obtain their carbon from the atmosphere by the absorption, in the presence of sunlight, of carbonic acid, which they decompose, liberating its oxygen in the process. Carbonic acid forms but a very small proportion of the atmosphere, which chiefly consists of nitrogen and oxygen, but that proportion is maintained by what is returned to it by the exhalation of animals as one of the products of their respiration.

In the British Islands agriculture is practically confined to various forms of mixed culture. There are farms which entirely consist of grass, but in such cases, if success is to be achieved, the occupiers must either employ purchased foods for the more generous feeding of their stock, or

A CHAMPION SHORTHORN BULL.
The property of Mr. Robert Taylor, Pitlivie, Carnoustie, N.B.

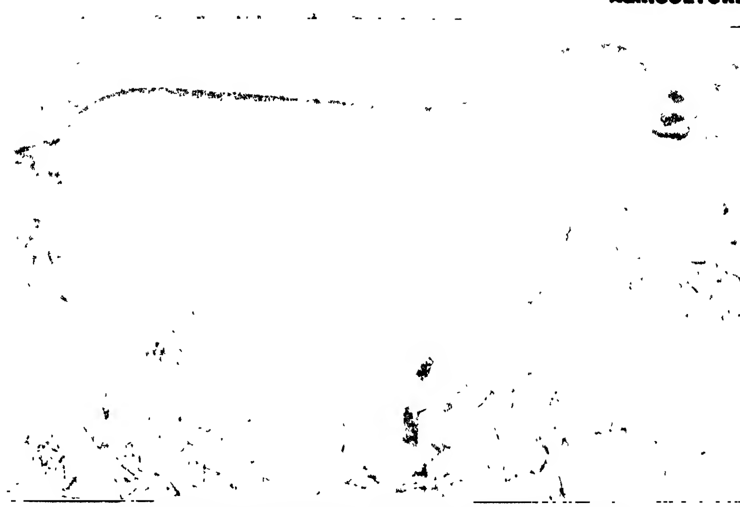
We depend upon the rain for a variety of reasons, and among them the following, which, perhaps, may be regarded as the most important. Water is essential to plants, inasmuch as it forms the largest portion of their composition, 14 per cent. in the case of the wheat-grain to 90 per cent. in the turnip. It is, too, the medium by which the mineral matter of the soil is conveyed to the plant and appropriated in the formation of its structure. Without water tillage would be impossible, and seed, if deposited, would be unable to germinate.

The Atmosphere. The atmosphere is also as essential to plant as to animal life, although for different reasons. The feeding materials of plants which are in greatest abundance are those which are known as the carbohydrates, chiefly consisting of starch and

where stock are neither fed nor bred and the crops are sold—and this would be a practice as unwise as it is uncommon—they must purchase manure to a considerable extent, and at a cost which would not be commensurate with the results.

The Rotation of Crops. Progressive farming, as it is now understood, entails what is known as the rotation of crops. It is true that by intensive culture and perfect cleanliness—by which we mean entire freedom from weeds—the same crops can in many cases be grown year after year upon the same soil, but owing to the inherent necessity for variety which is involved in the breeding and feeding of stock, the farmer finds it to his advantage to grow crops of various kinds, and by their assistance, the one helping the other, to

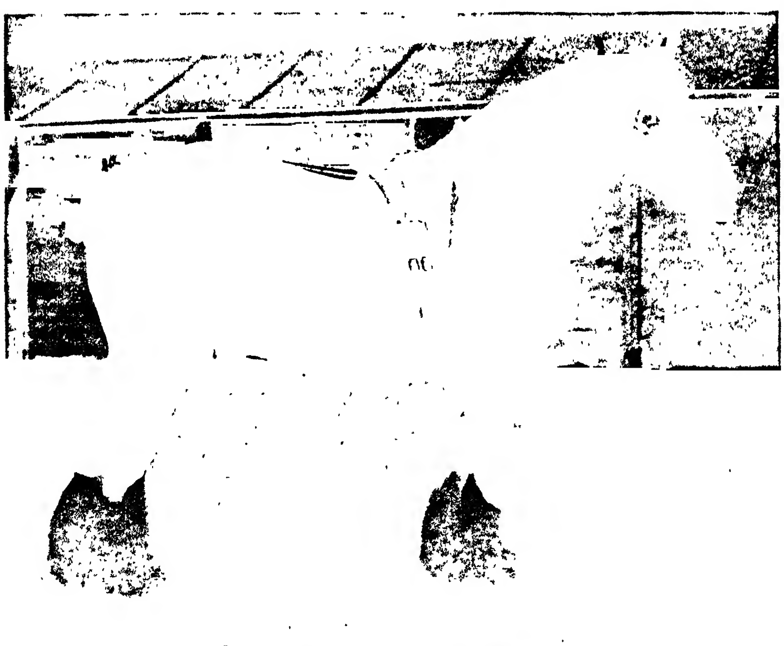
maintain cleanliness and at the same time to husband and even impart fertility. Root cultivation and destruction of weeds, which processes are applied to the mangel and turnip, as well as the system of manuring which is followed for their benefit, prepares the way for grain and pulse, for clovers and artificial grasses. In their turn the clovers and their leguminous allies, by the absorption of the nitrogen of the atmosphere, which takes place through the action of the bacteria which are found in the tiny nodules on their roots, enrich the soil with that element which is most of all essential to the prosperity of the cereals and of many other important plants.



A CHAMPION SOUTHDOWN RAM AT THE ROYAL SHOW.
The property of the King.

Systems of Farming. Our forefathers were aware that a clover crop was a good preparation for wheat and other grain crops, but they were unable to understand why it was possible to remove heavy crops of clover from the land, involving the loss of large quantities of plant food, and, therefore, apparently diminishing its fertility, and yet to obtain, what seemed contrary to Nature, larger crops of grain in succession than would otherwise have been the case. We now know that the chief element of fertility removed in clover, as in all similar plants, is nitrogen, as already suggested, but that a large proportion of the nitrogen absorbed still remains in the roots, which on decomposing provide a succeeding crop with a liberal supply.

Farming in the British Islands is conducted on diverse systems, all depending, apart from the inclinations of the cultivator, who, however, is largely controlled by Nature, upon soil and climate. Nevertheless, we may take one county — Yorkshire—as a type of England, for here we find systems as opposite in character as sand is to clay—sheep-farming on the Wolds in the East Riding, grain and pulse in Holderness, potato culture in the Vale of York, dairy farming



A CHAMPION SHIRE STALLION, DELAMERE CHORISTER.
The property of Lord Rothschild.

and grazing on the pastures of the West Riding, and the production of cattle in the North. If we would ascertain the influence of the rainfall we have only to look to East Anglia, where in consequence of its small percentage, cereals are chiefly grown, and to the western counties, whether Cumberland or Westmoreland, Devon or Somerset, where it is high, and where, as a result, pasture farming, the production of hay, and the grazing of stock is the dominant practice.

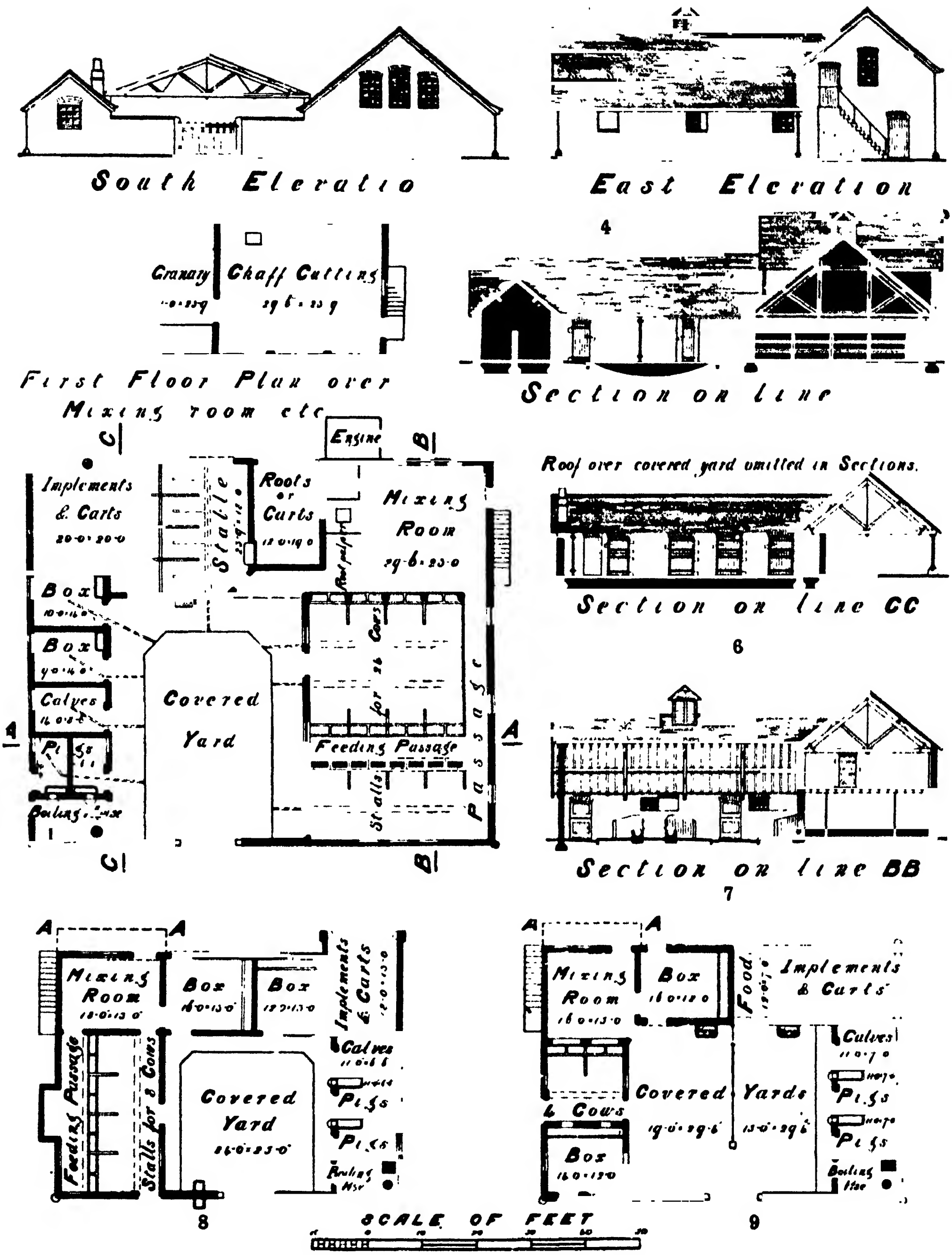
Sizes of Farms. In England, but for other reasons than those of soil and climate, the size of the farms is larger than in any other old and highly-civilised agricultural country; for example, the average area of the English farm is about 63 acres; in other countries, chiefly owing to the fact that the land is much more extensively owned by the people, the average size of each holding is much smaller. In France the average area is 15¼; in Germany 76 per cent. of the farms are under 12½ acres, in Belgium 715,000 farmers each occupy less than 10 acres, while in Denmark 161,000 farms are under 25 acres in extent. In Holland 79,000 farms out of 169,000 are under 12½ acres, while 143,000 are under 50 acres. The larger the area the larger the capital essential for the purpose of stocking and equipment; thus, while the English farmer chiefly employs his capital in the provision of live and dead stock, the Continental farmer employs it in land, and for this reason he is the chief factor or backbone of his particular country. Capital is essential for the successful cultivation of land. There is no system which is so advantageous as that under which stock and crops are made interdependent upon each other.

The Farmer's Beginnings. It will be apparent that the young farmer should thoroughly understand the principles by which the cultivation of the soil and the breeding and feeding of stock are governed. To imitate the practice of his father, valuable up to a certain point, is insufficient. He must learn, through knowledge of the influence of climate and of the soil in its various forms, how far he may take advantage of those crops and those classes of stock which have hitherto been strange to the land he occupies. This knowledge is especially valuable in the selection of a farm as well as in its improvement. He will naturally consider not only what has been accomplished by his predecessor, but how far that predecessor has failed for want of information. He will look for land to which the sun has constant access, to perfect drainage, to a general and constant water-supply, to substantial and easily maintained hedges or fences, to good roads, to access to market and rail, to convenient, simple, easily maintained and not too extensive buildings; to a healthy home, pure water for his consumption, and perfect sanitation. He will take care to learn not only how to buy stock foods and manures to the greatest advantage, but what and how to supply them to the stock and crops on his farm.

UNIVERSAL AGRICULTURAL MOTOR AT WORK: ATTACHED TO A SELF-BINDER.

Science and Practice. The improvement of a farm, whether it be naturally poor, or poor as the result of carelessness or bad workmanship, depends as much upon the knowledge, which is the result of latter-day investigation, as upon the practical experience of the cultivator. An improved farm returns larger crops and feeds more cattle than hitherto, and, therefore, it should produce a larger profit. Improvement, however, does not depend solely upon the cleaning of the land, the destruction of weeds, and liberal and judicious manuring, but also upon the deepening of the tilth by the plough, where, it may be for generations, it has never penetrated beyond a given depth, and that a superficial one; upon the variations of the crops by the introduction of those plants which under modern or advanced culture are now grown with success, and upon the feeding of a larger head of improved stock.

Average Yield of Crops. Again, the young farmer should make himself acquainted, not only with the average yield of each crop grown in this country, and especially of those



THE ARRANGEMENT OF A SMALL FARM OR A SMALL HOLDING

A decisive factor in farming is the arrangement and maintenance of outbuildings. The chief design on this page has been carefully worked out to meet, at the smallest possible cost, all the requirements of a farm of from 80 to 120 acres; and the smaller plans are for a small holding of from 30 to 60 acres.

The plan for the farm provides for stalls for 24 cows in the east wing; calves, pigs, and boxes occupying the west, with a convenient covered yard between the two. On the north side are stables, sheds and stores, with chambers over.

Fig. 8 shows designs well adapted to a small holding of from 30 to 60 acres, with milk production as its staple business, and 9 is a plan for a similar holding on which milk production and cattle-raising are combined.

These plans, based on the experience of 40 years of farm life, are by Mr. Samuel Taylor, Government Medallist in the Science and Practice of Agriculture, who has been awarded the Medal of Merit of the British Dairy Farmers' Association for the design of farm homesteads.

adapted to his own holding, but he should learn what is the possible yield of each under high cultivation. A study of a question like this may provide an incentive which may prove most serviceable. He may be inspired with a desire to emulate those who have succeeded far beyond their fellows, and who shall say that he may not equal their performances? The average yield of wheat, less than 4 quarters—or nearly 32 bushels—to the acre, and of oats, 39 bushels, is easily excelled on suitable soils—and this must always be an essential qualification—by the farmer who is thoroughly proficient, and whether we take the potato or the mangel crop, grass or clover, or, indeed, any plant or plants which are common to the farm, we shall find that the same argument applies. The average man obtains an average return; the tenant who has mistaken his vocation, and who was better adapted for some other form of industry, makes little or no praiseworthy attempt to excel whatever.

Training. How then should the young men who are the prospective farmers of the future be trained for prosperous life work? There are many who believe that a course of study at an Agricultural College is sufficient. There are others who regard it as imperative that they should take an active part in the practical work of the farm which is occupied by their fathers, and that nothing further is needed. Others, again, recommend a form of practical pupilage on the farm of a highly-skilled agriculturist. In neither case are these proposals sufficient for the purpose. Of the two we should prefer the man who had passed through a practical course of work on a farm rather than the student whose sole acquaintance with farming had been gained at an Agricultural College. Farmers have succeeded in the past, and will succeed in the future, without the advantage of scientific knowledge, although in many cases their observations possessed a scientific basis.

An acquaintance with the theory of agriculture and with those sciences upon which its principles are based is not sufficient to enable a man to conduct a farm with success. It must be remembered that successful farming involves the management of men, a personal acquaintance with the soil and power to judge of its condition under varying circumstances, a recognition of the character and quality of plants for the very necessary purposes of sowing and growing in suitable soils and climates, of harvesting at the right moment, and of selling to the best advantage. A farmer should be able to deal advantageously with his fellow-men, be he corn-merchant or butcher, stock-dealer or maltster; indeed, in a hundred ways he needs a form of practical training which is only possible on the farm, in the market, or on the corn exchange.

Scientific Education. A course of preparation for a farming career should include scientific as well as practical education in its various aspects. A lad who goes straight from school to an Agricultural College is not prepared for the work of which it is intended he should obtain a grip. He will be taught facts relating to soil, crops, and animals, of which, in all probability, he knows little or nothing: and at the close of his academic career he may be crammed with a form of knowledge valuable under other conditions, but which he is unable to apply in his daily life.

Far different is it with the lad of slightly more advanced years, who has spent two or three seasons upon the land, and taken part in all the varied forms of labour which its cultivation and the management of stock involves. He has reached a period of life when his receptive powers are active, and he rapidly learns to manage the implements and machines which are employed and the horses which draw them. He fully acquaints himself with the habits of livestock in all their varieties; with their requirements and with the methods of feeding which are employed. He obtains many hints from the workmen, with whose habits he becomes intimate. He enjoys attending the markets and fairs, the corn exchange, and the auction, and he gradually acquires a fund of information which is impossible under any form of scholastic training. Such a lad is in a position to take advantage of a course of instruction at an Agricultural College, and a couple of years, so far from being wasted, will, unless he is a dullard and utterly unwilling to work, be followed by a fairly comprehensive grasp in successful practice on the farm, of those scientific facts which explain the "reason why," and of those principles which once understood provide a foundation for a successful future.

Scientific knowledge, however, not only explains why certain practices are followed and results obtained, but it suggests; and under almost all circumstances it enables a thinking man who is at the same time a good practitioner to vary or to modify any part of his system, which is not precisely as prosperous as it might be, for the reason that he knows the cause and is in a position to suggest a remedy.

The Farm as a School. We do not for one moment despise the teaching which a farmer's son receives under his father's eye. It is well that he should begin his career at home, and learn the elements of practice and the necessity for a personal acquaintance with every form of farm labour before he commences his college course, which is in these days an almost imperative necessity.

That course completed, he may most advantageously spend six to twelve months upon each of two farms in different parts of the country where the work is of the highest class, where the soil and the climate differ, and where the crops and stock enable him to learn facts and to acquire a knowledge of practices which he has been unable to learn elsewhere, but which will provide him with a larger fund of information, and thus enable him to become less dependent upon local customs and conditions, climate and soil.

To be continued

BIOLOGY. EVOLUTION. HEREDITY. PSYCHOLOGY

A SYSTEMATIC ACCOUNT OF BIOLOGY, ZOOLOGY, EVOLUTION, AND HEREDITY

WITH A DESCRIPTION OF

THE GREAT PROBLEMS OF THE EVOLUTION OF BODY AND MIND

AND A BRIEF CONSIDERATION OF THE

Beginnings of Life	Life's Varying Conditions	Anthropology and Ethnology
Theories of its Origin	Fishes, Birds, Plants	The Theories of Evolution
Spontaneous Generation	Animals, Mammals, Reptiles	The Laws of Heredity

LEADING UP TO A STUDY OF

THE MYSTERIES OF PSYCHOLOGY AND THE REMARKABLE RESULTS OF PSYCHICAL RESEARCH

AND CONSTITUTING

A GENERAL SURVEY OF THE DEVELOPMENT OF THE INDIVIDUAL AND THE RACE

BY

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THE BEGINNINGS OF LIFE AND THE STUDY OF BIOLOGY

By Dr. Gerald Leighton

THE cultured man who sets out to learn what is known concerning the Science of Life is entering upon a subject whose scope is unlimited, because the subject is the largest in the world. If it be true that the proper study for mankind is Man, it follows that the investigation of the methods and principles by the operation of which Man has become the creature he is will embrace the most fascinating topics open to his research.

The very vastness of the subject is, however, a disadvantage. The serious student of Biology finds that the devotion of a life-time is hardly sufficient for him to familiarise himself with all that is to be learnt about one single branch of the subject. The great mass of this knowledge has been accumulated since the epoch-making work of Charles Darwin, whose observations and deductions opened up the way to fields of work and thought previously undreamed of. It is but the bare truth, indeed, to say that modern biological science dates from the publication of the "Origin of Species."

The Vastness of the Science. The inevitable result of this rapid accumulation of facts concerning the science of life was that it very soon became necessary for students to take up special branches of biology to the neglect of other branches, and at the present day any one of the various branches of the science provides material for a life's work. It is possible, indeed it is usual, for the expert in plant life to be quite ignorant of all that concerns the life of, say, a fish.

It cannot be otherwise. The biologist of to-day, if he is to add anything to the sum of human knowledge, must specialise; he must confine his studies to the life-history of a few types of life, or even to a single family or species. But, in order that he may do this to the best advantage, it is first of all very necessary that he should have a clear conception of all the great principles which govern the life of any kind of living organism. The danger of specialisation is that these great principles are apt to be lost sight of in a mass of minute detail. It is difficult to see all the facts of life in their true proportion when the mind's eye is constantly focussed upon a special point.

Phenomenon of Life. Now, as far as the man of culture is concerned, these minute details are of no importance: they do not help him to understand the problems of life, nor do they throw any light upon the ages that are gone. In order that they may be of any use to him these details require to be generalised, taken out of their special compartment of scientific knowledge and put in their place along with other facts of a similar kind, the whole sum of which point to the existence of a universal or general law. When, after years of specialised labour, sufficient data have been accumulated upon which it is safe to deduce general laws or principles, *then and then only is it time for a science to be included in any general scheme of education.*

The Science of Life—Biology—has reached that stage. It is no longer possible for any man to claim to be considered educated or cultured if he remains in ignorance of the great Laws of Biology. Without being either a botanist or a zoologist it is open to every man nowadays to learn much of how the world of living creatures has become what he sees it to be. It is not only possible; it is essential. There is no other way in which we can see the true proportion of things, there is no other way to "see Life whole."

Our object here is, therefore, to endeavour to gain a broad and comprehensive view of the most marvellous phenomenon of which we have any knowledge—the phenomenon of Life. And since, of all forms of life, that which is of supreme interest to man is his own life, we shall try to trace the means whereby a creature has been produced capable of undertaking the task of investigating himself. In order to do this, it will be necessary to go back to the simplest forms of life that are known, to see how they live and move and have their being, to study the various aspects of *their* life, to see how it became more complex according to changing surroundings, to explain why some things survived while others perished, and to discover how the survivors transmitted their priceless advantages to succeeding generations.

Life in its Simplest Forms. The important point to note at the outset is that, just as the simplest forms of life are single cells which perform all the functions necessary to life before any specialisation of function appears, so in the study of these phenomena must the student begin with what is general before attempting to study the special. Our attempt, then, is to trace life from its simplest forms, through its branchings and modes of transmission, to its highest development as manifested in the flight of a bird, the speed of a racehorse, the character and mind of Man.

Nature yields up her secrets unwillingly, and the secret of the nature of life has been inscrutably kept. We do not know what Life is. But we know what is *meant* by saying that an organism is living, and that definition is as far as we can go. We mean by Life that state of an animal, or plant, in which its organs are capable of performing their functions, or in which the performance of those functions has not permanently ceased. What we mean by Life is a series of definite and successive changes, both of structure and composition, which take place within an individual without destroying its identity. That is *what we mean*. Of the actual nature or essence of those changes we remain ignorant. No plausible or reasonable explanation has ever been put forward to account for the phenomenon of Life entering into non-living matter. We are utterly ignorant of how Life came to be.

Things that Cannot be Proved. Let it be carefully noted that we are speaking now of knowledge, not of beliefs. That is a distinction to be constantly kept in mind in dealing with science. *It is one thing to believe that a certain fact occurred, or that a certain process took place; it is quite a different thing to know it. One may believe many things, and they may be perfectly true, without its being possible to prove their truth.* The mental attitude in relation to such matters will be found to be mainly a matter of individual temperament. On matters which cannot be definitely proved one man will adopt the attitude of belief, another will be inclined to deny, whilst a cautious third will be content with asserting his ignorance. The one should have no cause of quarrel with the other. An unproved and unprovable dogmatic statement is helpful to some types of minds; it is a positive hindrance to others.

"How?" To many minds the question "How?" is non-existent. It does not present itself to them as a difficulty to be solved before they can believe. They have simple Faith. But one of the results of the evolution of the higher mental character of man has been to produce a speculative type of mind. Such a mind is not content with a bare dogmatic statement. "How?" is to it the one supremely interesting question. It seeks to account for processes by formulating theories based on facts. So long as the distinction between the attitude of belief and that of knowledge is kept clear, there is no cause, let us repeat, for quarrel between the two.

It is to the ever-growing spirit of research and curiosity that all progress of scientific thought is due, and so much light has been thrown upon the problems of life in the last fifty years that much which to our fathers was obscure is now becoming clear. But as regards the Origin of Life we are still without an explanation.

The reason is that this phenomenon stands alone. There is nothing else quite like it, or with which it can be compared. A hard and fast line seems to mark off the living from the non-living; there is no sign of the process by which the gulf could have been bridged in the first place. It is true that a theory known as that of Spontaneous Generation has been advanced to account for the origin of life, but it merely asserts that living matter arose from non-living, without explaining how. Spontaneous generation asserts the possibility of producing a living organism without the necessity of a pre-existing parent.

The Origin of Life. In the seventeenth century this was the prevailing view amongst naturalists and men of science, and it was sanctioned by antiquity. Its first assailant was Redi, an Italian philosopher. Needham and Buffon, both of whom have been commonly regarded as supporters of the hypothesis, held it in a modified way. "They held that life is the indefeasible property of certain indestructible molecules of matter which exist in all living things, and have inherent activities by which they are distinguished from non-living matter; each individual living organism being *formed by their temporary combination*, and they standing to it in the relation of the particles of water to a cascade or a whirlpool, or to a mould, into which the water is poured."

The doctrine of spontaneous generation is now held, oddly enough, by extreme evolutionists, under the name of Abiogenesis. A belief in abiogenesis means, simply, that at some period in the history of the universe there must have been a time and a process which resulted in the transformation of non-living matter into living protoplasm. It further involves the belief that this was a natural process and not the result of "supernatural" or "miraculous" interference. Biogenesis, on the other hand, as

maintained by Redi, is the belief that living organisms can spring only from pre-existing living parents. During the last half-century the belief in spontaneous generation largely lapsed, mainly on account of the work of Tyndall, Pasteur, and others. The present attitude of science in regard to this theory may be described as a reserved scepticism, the agnostic view, which does not deny the possibility of spontaneous generation or abiogenesis in some other and remote period of the world's history, but, reasoning from the failure of all experiments in that direction, is inclined to think that life *now* is produced only from life.

An Important Fact. The important fact for us to realise here is that living cells have the power of converting non-living matter into living protoplasm. "The simple constituents of the food are converted *step by step into the living substance of the plant by the agency of that substance itself.*"

Passing now from all speculation as to the origin of life, let us turn to the facts as they may be seen and studied in plants and animals, limiting ourselves to the description of a few of the principal types of animals, a knowledge of whose general plan of structure and mode of life every educated man should possess. For the rest, our object is to bring before the reader the great biological laws which have produced these creatures, and to endeavour to ascertain in what directions these laws are operating now. We shall begin with the higher forms and end with the lower, because most people know something of the anatomy and physiology of man, and also because those subjects are fully treated in PHYSIOLOGY. It will be presumed in what follows that the reader has made himself familiar, through other sections of this work, with the structure and functions of Man.

The Groups of Animals. The first scientific attempt to arrange animals in groups according to types was that of Aristotle (384–322 B.C.), who clearly recognised the fact that the whole animal kingdom represents a gradual transition from lower to higher forms. He also recognised that structure must be taken as the basis of classification. He therefore divided animals into two great groups, which correspond exactly with the modern division into Vertebrates and Invertebrates.

The great object of systematic classification is accuracy of description and convenience of reference. It is simply a means to an end. *It is arrived at by noting likenesses and differences. In this way the whole realm of animate life is divided into the two great groups of* **Plants and Animals.** The broad distinctions between these two are plain enough, but it is sometimes difficult, or even impossible, to say whether a given organism is to be regarded as a plant or an animal, or neither.

Taking first the Vertebrates, or back-boned animals, we find that there are five well-defined groups, viz., Mammals, Birds, Reptiles, Amphibians, and Fishes.

Essential Characters of Vertebrates. The description in PHYSIOLOGY of the structure and functions of Man gives an idea of the principal characteristics of the whole group, but we may summarise the essential characters of Vertebrates here. All possess a vertebral column or back-bone, from which the group takes its name. The body is bilaterally symmetrical always in the young animal, and generally in the adult. There is no obvious external division of the body into segments, but the internal structure indicates such a division. A longitudinal section through the body (such as may be seen in the carcase of a sheep in a butcher's shop) shows that it is made up of two tubes. One tube is dorsal, the other ventral. The dorsal tube consists of a narrow canal in the back-bone, which encloses the spinal cord, and this widens out into the larger cavity of the skull in which lies the brain. The ventral tube forms the cavity of the chest and abdomen, and contains the organs of those parts. Most vertebrates have limbs, and these are never more in number than two pairs. Of all these characters one of the most obvious and important is the enclosure of the nervous system in its own bony tube, separated from the rest of the body.

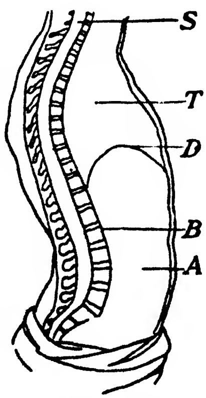
This double tube arrangement is a primary distinction between Vertebrates and Invertebrates, because in the latter, in all adults without exception, the body may be regarded as a *single* tube, which encloses all the viscera, and the nervous system is enclosed within the general body cavity, and is not in any way shut off. The contrast is well brought out by our diagram of a transverse section of a vertebrate and an invertebrate [**2**].

There is one other structure to which reference must be made in this connection. Between these two tubes, running along the axis of the trunk, is the back-bone—shown in the longitudinal section [**1**]. In the very lowest vertebrates, and in the embryos of higher vertebrates, there is in this position a structure termed the notochord. This is present in *every vertebrate embryo*, and represents the foundation of the spinal column or back-bone.

A Visible Transformation. We may note, further, that in all vertebrates, at some stage of their development, are some openings or slits at the side of the throat, forming a passage from the exterior to the pharynx. In terrestrial mammals, reptiles, and birds these slits are present in the embryo only, and are functionless, merely indicating that the ancestors of these creatures once had need of them. *In fish they persist as the gill-slits. In the development of an amphibian, such as the frog, the transformation from the stage possessing* gill-slits like a fish into a terrestrial animal breathing by lungs, can be actually seen.

It is hardly necessary to add that all vertebrates have a blood circulation through tubes, the propelling power being the heart; that the chief part of the nervous system is the brain, which is continuous with the spinal cord, and from both of which the nerves arise; and that the organs of sensation are in reality outgrowths of the brain.

Mammals and Birds. We may now indicate the predominating characteristics of the five great groups of vertebrates, noting only those points which mark them off from each other. The highest of these groups is that of the Quadrupeds, or Mammals, amongst which is man himself. Two striking characters at once call for notice—namely (1), the possession of *hair*, and (2) the presence of *milk glands*, by means of which the young are nourished for a longer or shorter period after birth. These two points are alone sufficient to separate the mammals from other vertebrates. Moreover, with the single exception of the lowly Monotremes of Australasia, all mammals bring forth their young alive, and do not lay eggs. In all mammals, too, the blood is warm; they are what are termed "warm-blooded vertebrates," in contradistinction to the fish and amphibians, in which the blood is cold.



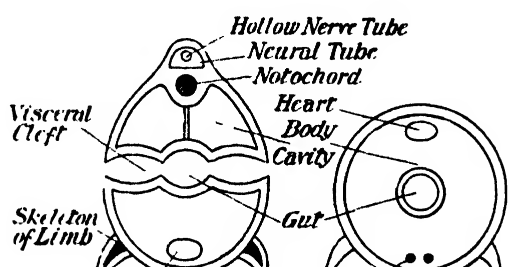
1. LONGITUDINAL SECTION OF VERTEBRATE TRUNK.

S. Spinal cord.
B. Backbone.
T. Thorax.
D. Diaphragm.
A. Abdomen.

Turning from the mammals to the familiar group of Birds, we recognise at once that the outer covering is not hair, but *feathers*, the growth of which largely determines the shape of the bird in nature, as will be realised if a plucked bird is compared with one with the feathers still on. The fore limbs take the form of wings, this being only one of the many adaptations for an aerial life presented by birds. The blood is considerably hotter than that of mammals, being on an average 103°F., compared with about 98°F. in mammals. All birds are egg-layers or oviparous; in no case are the young brought forth alive. "Oviparous vertebrates with a covering of feathers," sums up their characteristic features.

Reptiles. Both the groups just described — mammals and birds — have been termed warm or hot-blooded, which means that they possess not merely warm blood, but blood whose temperature is maintained at a fairly constant level, irrespective of external conditions. Associated with this state of the blood is the necessity of elaborate arrangements for breathing, and along with this warm blood is found the greatest physical activity and the highest degree of intelligence. In striking contrast with these two high vertebrate groups are the Reptiles, in which the blood is cold—that is to say, the temperature of reptile blood is approximately that of the surrounding medium, whether that be air or water. It is, therefore, warmer in hot weather than in cold. Broadly speaking, the result of this is sluggishness of movement and a low degree of intelligence. The external covering is entirely different from that of either mammals or birds. It usually takes the form of hard horny scales, as in snakes and lizards, whilst in some forms, as the turtles, large portions of the skin are ossified into plates. The breathing apparatus, as might be expected from the cold condition of the blood, is much simpler than in birds or mammals, and the reptile breathes by its lungs alone throughout life. Most reptiles are egg-layers, but some carry the young until fully developed, when they rupture the egg-membrane and are born ovo-viviparously.

Amphibians and Fish. The fourth group of vertebrates—the Amphibians—are often confused in the popular mind with the reptiles, but they are more nearly related to fish, as the reptiles are closer allies of birds. The important points of distinction are, therefore, those in which they differ from fish. In Amphibians, such as frogs, toads, and salamanders, true lungs are always present in the adults, while in the early stage of growth there are filaments which are adapted for breathing the air dissolved in the water in which the young amphibian is developing. Moreover, the limbs of amphibians are never converted into fins, and the external covering is soft, moist, and glandular, unlike that of either reptiles or fish. There are other minor points of difference which need not be noted here. Unlike mammals and birds, but in common with reptiles and fish, the blood of amphibians is cold.



2 CROSS-SECTIONS THROUGH A VERTEBRATE (A) AND A HIGHER INVERTEBRATE (B).

Lastly, among the true vertebrates, we have the Fish, which are always provided with gills throughout the whole of life. The blood is cold, and the limbs, when present, are but imperfectly developed, taking the form of broad expansions of the skin, called fins. The body is usually coated with a covering of scales. The shape of the body is adapted for rapid progression through the water, so that there is no obvious line between the head and the body, or the body and the tail.

It will be convenient for reference if the main points in these five groups be summarised in a table.

SOME DISTINGUISHING VERTEBRATE CHARACTERS.

Group.	External Covering.	Blood.	Breathing.
Mammals .	Hair	Warm	Lungs.
Birds . . .	Feathers. . . .	Hot	Lungs.
Reptiles . .	Scales or Plates	Cold	Lungs.
Amphibians	Soft and moist.	Cold	Gills first, then Lungs
Fish . . .	Scales	Cold	Gills alone

The Vertebrate Border Line. There has been no difficulty so far in selecting points of likeness and difference between animals which enable us to put them into certain well-defined groups. But when we leave the true vertebrates, or animals with back-bones, we come to creatures which seem to be on the Vertebrate Border Line. Until comparatively recent times they were regarded as Invertebrates, because in them there was not a true back-bone. But, as was pointed out when describing the essentials of a Vertebrate, this structure is preceded by what is termed the notochord, the firm rod which runs longitudinally below the spinal cord. It was also stated that vertebrate embryos exhibit at one stage the presence of slits in the pharynx; and, thirdly, that typical Vertebrates possessed a nervous system above the notochord, which was in the form of a tube. Now, if these three great characters be taken as the test, it is found that certain very primitive forms have some claims to rank as vertebrates One of these is the small fish-like creature known as a *Lancelet;* another is the curious *Sea-squirt;* and there is a third group represented by a worm-like animal, called *Balanoglossus.*

In the case of the Lancelet, there is a well-developed notochord present; no gill-slits are to be seen outside, but are found on dissection within, and above the notochord there is a tubular nerve cord. So that this curious little creature—it varies from 1½in. to 3in. or so in length—conforms to the three standard tests of a vertebrate. It is, at any rate, on the border line; it is almost a true vertebrate.

The Wonderful Sea-Squirt. In the second form—the Sea-squirt—only one of these three characters is obvious—namely, the perforation of the pharynx for breathing purposes. But if the development be studied, additional evidence is forthcoming in the shape of a notochord in the tail region Moreover, the young sea-squirt possesses a hollow brain and spinal cord. As the creature grows older, after swimming about freely as a sort of tadpole, it changes its mode of life and becomes sedentary, attaching itself to some rock or other object. Then some remarkable changes follow. The tail, with its portion of notochord, gets smaller and smaller and finally vanishes, and the nervous system, which was hollow, is altered into a solid mass, or ganglion. "We have, therefore," says Professor Ainsworth Davis, "the remarkable phenomenon of an animal which, when young, possesses the distinctive vertebrate characters, but loses most of them in the adult condition, becoming, so to speak, of lower grade. This is a good example of biological degeneration." It shows, also, that it is necessary to study the whole life-history of an animal before it can be thoroughly understood.

The third form which we have referred to as on the vertebrate border-line is a worm-like creature without a popular name, technically called Balanoglossus, found widely distributed in the world, dwelling in mud or sand. Gill-slits are found on the upper side of the trunk, a small notochord projects into the proboscis, and what represents the nervous system in this creature is a more or less hollow tube in the region of the collar. So that here again is the indication of the vertebrate border-line.

Creatures without Backbones. We have now sketched in outline the chief features of the Vertebrate animals, and it remains to indicate some of the features of the remaining mass of animals, all of which come under the general heading of Invertebrates.

This enormous collection of creatures without back-bones is divided into a great number of separate groups, each group on the same footing as the Vertebrates. These many divisions are matters for the systematic zoologist; all that is required here is to draw attention to the great diversity of form included in the Invertebrate group. They differ among themselves far more widely than do the vertebrate sections; indeed, there is very little in common between one of the lowly invertebrates and one of the higher, except the common absence of anything in the shape of a back-bone.

Let us take in imagination one of the higher invertebrate forms—a lobster, for example—and look at the great distinctions between such a creature and one of the lower vertebrates, such as a fish. A careful analysis will establish the presence of the following characters:

1. A protective hard external covering, but no internal skeleton corresponding to a skull or back-bone.

2. The body is composed of a single tube, not a double one.

3. The sides of the pharynx are not perforated by gill-slits.

4. The central part of the circulation, the heart, is dorsal instead of ventral as in a vertebrate.

5. The nervous system is composed of a ring round the gullet, continued backwards as a ventral nerve-cord.

We have already said that this great division of the animal world, the Invertebrates, includes a number of widely-differing groups, some of which are small in the number of their species, while others include myriads of creatures. They will be found dealt with in another part of this work [see NATURAL HISTORY].

To be continued

A SHORT DICTIONARY OF TERMS IN BIOLOGY

ABDOMEN—In vertebrates, the hinder part of the trunk, containing the principal organs of digestion and excretion.
Abiogenesis—Spontaneous generation, or the production of living beings without pre-existent life.
Accretion—The process by which inorganic bodies grow larger.
Adaptation—The adjustment of animals or plants to surroundings.
Albinism—Whiteness or paleness.
Albumen—The complex substance of which the white of egg is composed
Ambergris—A concretion formed in the intestine of the sperm-whale.
Amœba—A unicellular animal which changes its shape.
Amœboid—Like an amœba, changing in form.
Amphibia—One of the five Classes of vertebrates.
Anabolism—The chemical processes which build up the tissues
Analogous—Having the same function.
Anatomy—The study of structure.
Antenna—A feeler of an insect.
Anterior—Towards the front of the body.
Anthropoid—Man-like.
Aorta—The great artery of the body.
Artificial selection—The production of breeds by human agency.
Asexual—Reproduction in which sexes are not concerned.
Atlas—The name of the first vertebra in the neck.
Auricle—One of the cavities of the heart.
Aves—The class of Birds.
Axis—The second vertebra of the neck.

BILATERAL symmetry—Having right and left sides alike
Biology—The science of Life and living things.
Blubber—A thick layer of fat under the skin.
Body cavity—The space within the body-wall.
Brachial—Pertaining to the arms.
Branchial—Pertaining to the gills.
Bronchus—A branch of the wind-pipe.
Bud—An outgrowth which becomes an individual animal.

CALCAREOUS—Pertaining to lime.
Canine—Dog-like, applied to certain teeth.
Carnivorous—Flesh-eating.
Carpus—The wrist, the small bones between the forearm and hand.
Cartilage—Gristle.
Caudal—Pertaining to the tail.
Cell—The unit of structure, a nucleated mass of protoplasm.
Cephalic—Pertaining to the head.
Cerebellum—The small or hinder brain.
Cerebral hemispheres—The highest part of the vertebrate brain.
Cervical—Pertaining to the neck.
Chlorophyll—Green colouring matter of plants.
Choroid—The pigmented middle coat of the eye.
Cilia—Hair-like minute filaments projecting from the surface.
Ciliary action—The movement of cilia.
Clavicle—The collar-bone.
Cloaca—The cavity into which the excretory organs open, as in a frog.
Commensalism—The association of two organisms to the advantage of one or both.
Conjugation—The fusion of two individuals for reproductive purposes.
Crop—A part of the gullet for temporary food-storing.
Cross-fertilisation—Fertilisation of an egg by a sperm from another organism.
Cross-pollination—Transferring pollen from the stamen of one flower to the stigma of another.
Cytode—A simple portion of protoplasm without a nucleus.

DEGENERATION—The process by which organisms become parasites or fixed.
Development—A series of changes in the early life of an animal during which it passes from the state of a single fertilised cell to the adult condition.
Digitigrade—Walking upon the digits.
Distal—The end of a limb or extremity furthest from the trunk.
Dorsal—Pertaining to the region of the back.

ECTODERM—Outer cellular layer of the organism.
Embryo—The young animal during development within the egg or womb.
Embryology—Science of development
Endoderm—The inner cellular layer of an organism.
Endoskeleton—Internal hard supporting structures, as bones.
Epigenesis—Gradual development from the simple to the complex.
Exoskeleton—External hard supporting structures.

FEMUR—The thigh-bone.
Fertilisation—The fusion of two masses of germ-plasm
Fission—Reproduction by splitting of the parent cell.
Fossils—The remains of organisms or their traces in rock.

GAMETE—An unfertilised germ cell.
Gemmation—Reproduction by budding.
Genus—A group including one or more species.
Gill—An organ for breathing the air contained in water
Gizzard—A part of the digestive tube in which food is broken up.

HERBIVOROUS—Eating plants.
Hermaphrodite—Having the two sexes united in one individual.
Hibernation—Passing into a torpid condition, as in reptiles
Histology—Science of minute structure.
Homologous—Having a similar origin; constructed on a similar plan.
Host—The organism which carries a parasite.
Hybrid—An individual produced by crossing two species.

IMAGO—The adult stage of insects.
Incisor—The front tooth in mammals.
Invertebrate—Without a backbone.

LABIUM—The lower lip, in insects.
Labrum—The upper lip.
Larva—A young animal which has left the egg and is free, but incompletely developed.

MACRONUCLEUS—The large nucleus in some organisms.
Melanism—Unusual darkness of colour.
Mesoderm—The middle cellular layer of organisms.
Metabolism—Chemical change in body.
Metamorphosis—The period in the life of some insects during which the change occurs from the larva to the imago.
Metazoa—Many celled animals.
Micronucleus—The small nucleus in some organisms.
Mimicry—Resemblance between species, often for protection.
Morphology—Science of structure.

NATURAL selection—The survival of individuals which possess advantageous variations.
Neural—Pertaining to the nervous system.
Notochord—A supporting rod under the central nervous system in all vertebrate embryos, usually replaced later by the backbone.
Nucleus—The specialised portion of protoplasm within a cell.

OCCIPITAL—Pertaining to the back of the head.
Omnivorous—Having a mixed diet.
Ontogeny—Individual development.
Ovary—The female sexual gland.
Oviduct—The tube from the ovary to the exterior.
Oviparous—Producing eggs, or producing young from eggs.
Ovoviviparous—Producing young from eggs hatched within the body.
Ovum—The female sexual cell, the egg.

PARASITE—An organism which lives on or in another.
Parthenogenesis—Production of new individuals from unfertilised eggs, and therefore without the male element.
Pentadactyle—Having five digits
Permanent dentition—The second set of mammalian teeth
Phylogeny—The evolutionary history of animals.
Phylum—A large division of the animal kingdom, *e.g.* Vertebrates.
Plantigrade—Walking upon the palms of the hands or soles of the feet.
Protoplasm—Physical basis of organised tissues; simplest form of living matter.
Protozoa—Lowest division of the animal kingdom.
Pupa—A stage in insect life.

REGENERATION—The process of repair after injury.
Reversion—The appearance of traits like those of remote ancestors.

SEGMENTATION—Early divisions of an egg after fertilisation; also the division of an individual into rings or segments.
Self-fertilisation—Fertilisation of an egg by a sperm from the same individual.
Self-pollination—Transference of pollen from stamens to stigma of the same flower.
Soma—The body as distinct from the germ cells.
Somatic—Pertaining to the body as opposed to the germ cell.
Special creation—The belief that species were created independently.
Spermatozoon—The male sexual cell.
Spinal cord—The hinder part of the central nervous system.
Stigma—An air tube in insects. The pollen-receiving organ in plants.

VACUOLE—A space in the protoplasm of a cell.
Variation—The appearance of new traits.
Vegetative propagation—Reproduction by other methods than egg-production, *e.g.* budding or fission.
Ventral—Pertaining to the lower aspect of the body.
Vestigial—Pertaining to an organ which has undergone reduction.
Visceral clefts—The slit-like openings on each side of the throat which every vertebrate embryo exhibits.
Viscera—Organs within a body-cavity.
Viviparous—Producing young alive.

WARNING colouration—Conspicuous colouring of organisms which have dangerous or unpleasant traits.

ZOOGEOGRAPHY—The distribution of animals on the earth.
Zoology—The science of animals.
Zygote—A fertilised germ-cell

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A FIRST LESSON IN THE THEORY OF MUSIC

By J. Cuthbert Hadden

EVERYBODY knows a musical sound when he hears it. How is such a sound produced? "By vibrations or movements excited in the air which surrounds us," says the man of science. These vibrations may be set in motion in various ways—by the human voice in singing, by the agitation of a string, by the forcing of a column of air through a tube—as in wind instruments—by the striking of a sonorous substance. If the resulting vibrations are very slow, the ear receives no impression of them; if they are broken and irregular, the product is not music but noise.

Musical sounds are, therefore, to put it in a word, the result of rapid and regular vibrations of the air. Such sounds may be high or they may be low. When they are high, the vibrations producing them are very rapid; when they are low, the vibrations are proportionately slow.

Two Main Essentials. Thus we have musical sounds as they strike on the ear. How are we to represent them on paper, so that they may be produced by voice or instrument at will? This is the subject of our present study—the notation of music. In providing a written "language" for music, two main essentials have to be considered: (1) the pitch—that is, the acuteness or the gravity—of sounds; (2) the length or duration of these sounds.

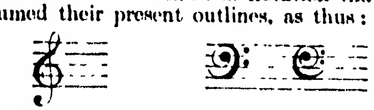
To determine the pitch, a series of lines and spaces called the *Staff* or *Stave* is used, with the addition of "Clef" signs, to be explained presently. Looking at a single "part" in any musical composition, it will be found that it is set down upon a Stave of five lines; but in theory the Stave must be regarded as a great ladder of eleven lines and ten spaces, broken up into two divisions merely for convenience of "reading." Vocal music was naturally the first consideration of those who devised a notation; for voices are old as creation, while instruments were a later evolution. A man's voice is lower than a woman's: he sings from the lower part of the Stave; the woman sings from the upper part. Hence it came about that the Great Stave of eleven lines and ten spaces was split up into halves. With eleven lines it could not be equal halves, of course, so the middle line was omitted, to be introduced as a short line only when required. The final result was therefore like this:

The original Great Stave should, nevertheless, form the basis of the student's theoretical knowledge. These lines and spaces are counted from the bottom upwards. Musical sounds are named after the first seven letters of the alphabet, and the stave lines represent, in their order, the

sounds G, B, D, F, A, C, E, G, B, D, F, while the spaces represent A, C, E, G, B, D, F, A, C, E.

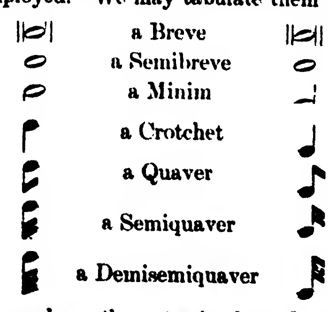
The student is strongly advised to learn these names by heart before proceeding. He must not be content until he can give at once, without hesitation, the name of any line or space within the entire range of the Great Stave. For those who are looking forward to playing an instrument this is especially essential. The singer may grope his way about, guided by a possibly good ear, but the instrumentalist must *read* his notation.

Clefs. Having cut up the Great Stave into two little staves, as it were, the question came to be how to indicate which part, the upper or the lower, was in use. It was with this object that the now familiar *Clefs* were introduced. "Clef" is the French word for *Key*, and these clefs are the keys by which the respective halves of the Great Stave are determined. In old music several clefs were used, and several clefs are still used in full scores; that is to say, in written orchestral music. In all ordinary modern music, however, only two clefs are found. They are known commonly as the Treble and Bass Clefs; more correctly as the G and F Clefs. The names in the latter case are derived from the position assigned to the respective clefs, the one turning on the G line of the Treble Stave, the other having its centre on the F line of the Bass Stave. As a matter of fact, these clefs were originally written in the form of the letters G and F; and it was not until far on in the evolution of musical notation that they assumed their present outlines, as thus:

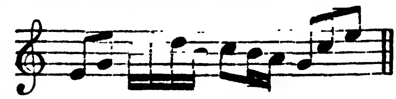


Treble Clef. Bass Clef.

Notation. The supporting fabric of written music being thus provided, we have to consider what to place upon it. This brings us to the question of notation proper—the symbols by which the pitch and duration of musical sounds are represented. If pitch alone had to be determined, one character would serve the purpose. But musical sounds may be of various lengths, as well as of different pitch, and to distinguish these lengths seven forms of note are employed. We may tabulate them thus:

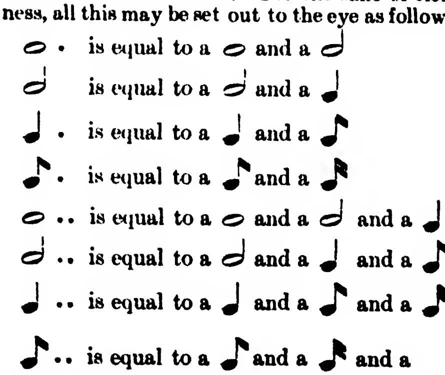


Here we have the notes in the order of their time value, each note being twice the length of the one which succeeds it; so that if, for example, you count four for a semibreve, you will count two for a minim, one for a crotchet, and so on proportionately. Observe that the tails of the notes may be turned up or down at pleasure. In the case of "tailed" notes with hooks, the hooks are often drawn together when two or more such notes appear consecutively, thus:



This "tying" of tails in no way affects the time value of the notes; in many cases it is done just because the notes look better when written in that way. With regard to the breve, the first note shown in the above table, this will be found, as a rule, only in Church music. In very old music notes of even greater length were used, but these are now discarded. In the matter of time, modern music may be said to begin with the semibreve.

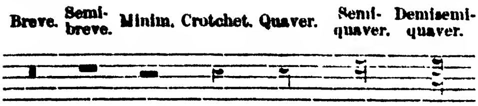
Time Values. Now look at the notes again. The semibreve, let us say, will last while we count four. Suppose we want it to last while we count six? There are two ways in which this may be indicated in writing. We may "tie" a minim to the semibreve, or we may add a dot. The latter is the more usual way of increasing the length of a note. The formula of the theory books is this: A dot after a note adds to the note one-half of its own time value. Thus, a dotted semibreve is equal to a semibreve and a minim; a dotted minim to a minim and a crotchet; a dotted crotchet to a crotchet and a quaver; and so on. Sometimes a second dot is required, when the time-value of the note is increased by three-quarters of its own length. Stated in another way, the second dot takes half the value of the first dot. For the sake of clearness, all this may be set out to the eye as follows:



A third dot, having half the value of the second dot, is used rarely.

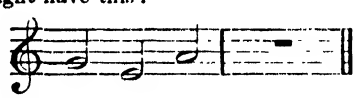
Rests. So much for the relative duration of notes. What if we want an absolute silence now and again? How is the silence to be indicated? This brings us to the question of *Rests*. Every note—semibreve, minim, crotchet, etc.—has its corresponding rest, whose time-value is exactly that of the note which it repre-

sents. Here are the forms of these different rests:

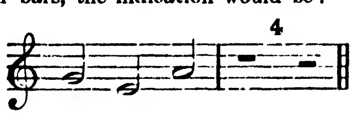


The student will find a little difficulty in readily distinguishing the semibreve from the minim rest and the crotchet from the quaver rest. Let him try to remember that the semibreve rest hangs from the line, while the minim rest sits on the line; that the head of the crotchet rest is turned to the right, whereas that of the quaver rest is turned to the left. On the Continent they have a more distinctly-figured quaver rest, written thus 𝄽, which is occasionally introduced in English music.

In ordinary usage rests are no trouble to the reader of music who knows the notes for which they stand and the time-value of these notes. The respective rests are simply the equivalent silences of equivalent sounds. But there are one or two unusual usages connected with them, of which the student must make careful note. For example, the semibreve rest is employed to indicate silence for a whole measure or bar (bars will be explained further on), no matter what the length of the measure may be. Thus we might have this:

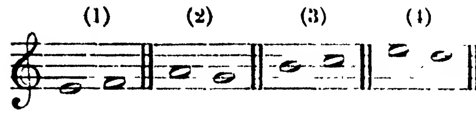


Here the semibreve itself would have represented the time of only two minims, whereas its rest is made to represent the time of three minims. On the other hand, silence for several bars is generally indicated by the appropriate rests, with the number of bars written in a plain numeral above the Stave. Thus, if the single bar rest of the last example were to be extended to four bars, the indication would be:



Other occasional peculiar usages find, as a rule, an easy explanation in the context. Rests, of course, may have dots placed after them to lengthen their time-value, just as in the case of the notes they represent. In practice, however, rests are much less frequently "dotted" than notes.

Scales. We have seen how the musical sounds represented by the first seven letters of the alphabet are represented on the Stave. Now we have to consider how these seven sounds may be modified. We shall speak of scales again in more detail. Meantime, let us run up the scale which begins on the note C. If the student has a pianoforte or a similar keyed instrument at hand, he should refer to it. He will find that only between the keys E and F, and B and C, is there no other key—no "black" key. This illustrates and emphasises the fact that the notes written on adjacent lines and spaces of the stave are not all equi-distant in the matter of sound. Look at this:



If you play (1) and (3) on the pianoforte, you will find that in both cases there is no note between; while, if you play (2) and (4), there *is* a note between.

Well, this intermediate note represents that modification of the foundation notes of the musical alphabet of which we have spoken. Between E and F, and B and C, the pianist (say) cannot place any other note: the distance, technically termed a semitone, is too small to be disturbed. All the other steps of the musical alphabet (C–D, D–E, F–G, G–A, A–B) represent a whole tone; consequently we can throw in a half-tone between each two. The question now is, how are we to indicate this modification, these extra notes, in our written notation?

Sharps and Flats. This introduces us to the *Sharp*, *Flat* and *Natural*, which are written in this way:

Sharp ♯. Flat ♭. Natural ♮.

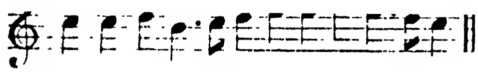
The names are almost self-explanatory. The sharp raises the pitch of a note a semitone; the flat lowers a note, also a semitone. The natural, again, restores a note which has been sharpened or flattened to its original pitch. Double sharps (written thus: X) are often employed, raising a note two semitones; double flats (♭♭), seen less frequently, lower a note also two semitones. It is unnecessary to illustrate in notation the use of sharp and flat. Observe, however, that either of these inflecting signs applied to a note affects any repetition of that note in the same bar or measure. Thus if we write:

the second G will be "sharp" like the first. In order to have it otherwise, we must introduce the natural, thus:

Another usage of the sharp and flat is more confusing. When the last note in a bar has been affected by either of these signs and the following bar begins with the same note, the inflecting sign continues in force. Careful musical writers, however, generally repeat the sign in the new bar to avoid misconception. In the case of double-sharpened and double-flattened notes, it often happens that a restoration to the single-sharpened or single-flattened

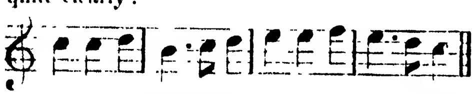
note is required. Here the indication is made by the use of the natural, as thus—♮♯; ♮♭. When certain notes are to be permanently sharpened or flattened—that is to say, throughout a composition, or part of a composition—the requisite sharps or flats are written at the beginning once for all. This results in what is called the *key-signature,* which will be explained more fully later on.

Bars. Reference has already been made to measures or bars. A musical composition is cut up into short sections of equal value, just as a footrule is divided into inches and half-inches. Without this, music would be almost meaningless to the eye, and, in its rendering, supposing it could be rendered, altogether unsatisfactory to the ear. For in music which is to give any pleasure at all, one very essential feature must be present—the regular recurrence of strong and weak accents or beats. Here are the first two lines of "God save the King" without "barring":



Supposing a vocalist, totally unacquainted with this melody, were to try to sing it from the above example. How is he to know that he must put the accent on the 1st, 4th, 7th, and 10th notes? Supposing he were to place the accent on any but the right notes, how it would distort the familiar air! We should not recognise it, in fact.

Here, then, is the object of having music dealt out in bar lengths: it enables us to fix the place of the strong accent, which always follows the bar-line. Thus, the two lines of "God save the King," when barred, come out quite clearly:



In ordinary phraseology the portion of music between two bar-lines is called a *Bar;* less frequently it is called a *Measure,* which is nevertheless the more correct designation. Two-bar lines, termed a *Double Bar,* are used to mark the close of a composition or an important section thereof.

Beats. Just as a composition is divided into bars, so the bars themselves are divided into equal portions called *Beats.* The beats are, as regards accent, strong, medium, or weak. There are different ways of arranging these accents, and according to the particular arrangement so is the nature of the "Time." Writers on musical theory are not uniform in their designations of certain subdivisions of time, but for all practical purposes the terms "Duple," "Triple," and "Quadruple" are sufficient. They are, moreover, preferable to other terms (such as "Common Time"), because they explain themselves. Thus Duple Time has two beats in the bar, the first strong, the second weak; Triple Time has three beats, in the order strong, weak, weak; and Quadruple Time has four beats, strong, weak, medium, weak. In all kinds of time the strong beat is at the beginning of the bar.

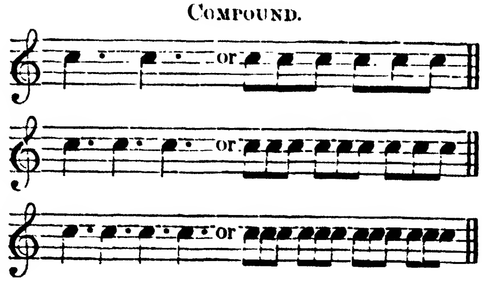
The student will understand that whether music is written in duple, triple, or quadruple time, either minims, crotchets, or quavers can be taken to represent the beat. Thus a bar of triple time may be written in each of the following forms:

It does not follow that there must be exactly 3 minims, 3 crotchets, 3 quavers in every bar of triple time; but there must be the equivalent either in notes or rests. The chief point to notice just now is, however, this—that when the beat is represented by minim, crotchet, or quaver, the time is called "Simple." A qualifying adjective is thus added to the three terms Duple, Triple and Quadruple.

Further, a "Simple" Time obviously implies a time that is not "simple." Hence we get the technical term "Compound." Briefly, the time is "Compound" when the beats are of the value of dotted notes. We may put it all another way, and say that Simple Duple Time applies to measures of 2 beats; Simple Triple to measures of 3 beats; and Simple Quadruple to measures of 4 beats. Compound Duple Time has 6 beats in the measure; Compound Triple Time 9 beats; and Compound Quadruple Time 12 beats. The difference may be readily represented to the eye:

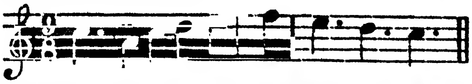
SIMPLE.

COMPOUND.



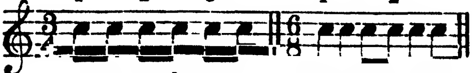
Compound time is generally written in quaver time; that is, the under figure of the signature (to be explained shortly) is usually 8, as $\frac{6}{8}$, $\frac{9}{8}$, $\frac{12}{8}$. It can thus be readily recognised by the grouping

of the quavers into threes, or by the prevalence of dotted crotchets:



Here are two measures containing the same value in quavers, wherein we can only decide the time by the *grouping* of the notes:

1 2 3 1 2



3 accented notes. 2 accented notes.

But the reader of music is not required to examine the measures themselves in order to determine the kind of time. At the beginning of every piece of music he finds a sign called a *Time-signature*. These time-signatures, consisting of an upper figure and a lower, are based on the semibreve as the standard of measurement, and to that note their figures bear direct reference. Thus the signature $\frac{2}{4}$ indicates two-fourths of a semibreve, that is, two crotchets (or their equivalents) in a bar. In like manner $\frac{3}{8}$ means three-eighths of a semibreve (three quavers). In all Simple Time signatures the number of beats in the bar is expressed by the upper figure, which therefore never exceeds 4. Unfortunately, the Compound Time signatures do not so clearly express the number and value of the beats. In this case the figures indicate the notes obtained by dividing each of the beats in a bar into three equal parts. Thus Compound Duple Time would be expressed by $\frac{6}{8}$; that is, six quavers. In all Compound Time signatures the number of notes obtained by dividing each beat into three equal parts is indicated by the upper figure, which therefore is never less than 6.

Time Signatures. It will be best to give a complete table of Time Signatures for reference in case of doubt.

	SIMPLE TIME.		COMPOUND TIME.	
DUPLE (2 beats in the bar).	𝄵 or $\frac{2}{2}$	2 minims	$\frac{6}{4}$	2 dotted minims
	$\frac{2}{4}$	2 crotchets	$\frac{6}{8}$	2 dotted crotchets
	$\frac{2}{8}$	2 quavers	$\frac{6}{16}$	2 dotted quavers
TRIPLE (3 beats in the bar).	$\frac{3}{2}$	3 minims	$\frac{9}{4}$	3 dotted minims
	$\frac{3}{4}$	3 crotchets	$\frac{9}{8}$	3 dotted crotchets
	$\frac{3}{8}$	3 quavers	$\frac{9}{16}$	3 dotted quavers
QUADRUPLE (4 beats in the bar).	𝄵 or $\frac{4}{2}$	4 minims	$\frac{12}{4}$	4 dotted minims
	𝄴 or $\frac{4}{4}$	4 crotchets	$\frac{12}{8}$	4 dotted crotchets
	$\frac{4}{8}$	4 quavers	$\frac{12}{16}$	4 dotted quavers

Of these eighteen forms, $\frac{2}{8}$, $\frac{9}{4}$, and $\frac{12}{4}$ are very rarely met with.

Having got our musical composition divided into bar lengths, with time- and key-signatures prefixed, we still want to have some indication of the pace and general manner of its performance. As to the pace, that is most accurately indicated by what is known as a metronome mark. A metronome is an ingenious little clockwork machine with a dial and a pendulum, which may be shortened or lengthened at pleasure. There is a regulator on the pendulum, and that regulator, placed opposite the dial figure named by the composer, determines the speed of his music. Thus 𝅗𝅥 60 means 60 swings of the pendulum in a minute, each swing representing one beat of the music; in this case the duration of the minim. The metronome, therefore, mechanically and precisely measures the rate, just as the pedometer measures the walking speed of the pedestrian.

Musical Terms. But it is not always necessary to be so precise in the matter of time. It is enough, as a rule, to indicate the general character of a composition, and this is done by means of certain terms with which the student must familiarise himself. A list of these terms is given at the beginning of this course; here it will be sufficient to name those most commonly used, so that the student may look them up in the Glossary. In alphabetical order they are:

Adagio.	*Largo.*
Allegro.	*Larghetto.*
Allegretto.	*Lento.*
Andante.	*Moderato.*
Andantino.	*Presto.*
Grave.	*Prestissimo.*

The application of most of these terms is extended and modified by certain qualifying words, such as *molto* (very), *non troppo* (not too much); *con moto* (with motion); *assai* (more, extremely); *meno* (less); *piu mosso* (more moved, quicker); etc., etc. Thus *Allegro con moto* means with more than the usual degree of motion; *Allegro non troppo*, quick, but not too quick; *meno allegro*, less fast; and so on. In this connection it is well to notice such terms as *Accelerando* (accelerating the pace); *Ritardando* (retarding); *Ritenuto* (holding back); and *Rallentando* (slackening the pace). When the composer desires that the former strict time be resumed after an *Accelerando* or a *Rallentando*, he writes *A tempo* (in time). It should be pointed out, perhaps, that there is some confusion among theorists about the relative value of the terms *Andante* and *Andantino*. The latter is the diminutive of *Andante*, and ought therefore to mean "less going"; but as a matter of fact it seems to be most frequently used to signify "less slowly" (than *Andante*). In regard, however, to the whole subject of pace and mode of performance, it may be observed in the words of Professor Banister, that good compositions to a large extent "tell their own tale, indicate their own character," and it must be left to the performer's judgment to execute them accordingly.

To be continued

A SHORT DICTIONARY OF TERMS IN MUSIC

ABENDLIED—An evening song.
Accelerando—More and more quickly.
Acciaccatura—A short grace note (see text).
Adagio—Leisurely, deliberately.
Ad Libitum — At the performer's pleasure as to time.
Agitato—In an agitated style.
Alla Breve—The time with two minims in a bar; seldom used in modern music.
Alla Cappella—In the church style.
Alla Marcia—In march style.
Allegretto—Light and cheerful; not so fast as *Allegro*.
Allegro—Lively, briskly; in a gay and merry way.
Allemande—A German dance tune in triple time.
Al Segno—To the sign (see text).
Alt—All notes in the octave above G in top space of treble-clef are said to be *in alt*.
Amore, Con—With tenderness.
Andante — Literally, going, walking; going easily, fluently, moving on.
Andantino—Slower than *Andante*.
Animato—Animated, usually as to speed.
Anthem — A sacred composition for voices, words usually Scriptural.
Appassionato—Impassioned, with feeling.
Appoggiatura—A grace note (see text).
Arpeggio—Notes of a chord played in succession (see text).
Assai—Very, as *Allegro assai*, very quick.
A tempo—In time.
Attacca—Attack; without pausing.
Aubade—A morning song.

BAGATELLE—A trifle; a short easy piece.
Barcarolle—A song or composition in imitation of the Venetian gondoliers.
Ben—Well; as *Ben Marcato*, well marked.
Berceuse—A cradle song, a lullaby.
Bis Twice (see Text).
Bolero—A Spanish dance in triple time.
Bourrée—An old French dance in triple time.

CADENZA—An ornamental passage, often improvised at the close of a composition.
Calando—Literally, falling away; gradually softer and slower.
Canon—A composition in two or more parts in which the parts continually imitate each other.
Cantabile—In a singing, melodious style.
Cantata—A choral composition of several movements, with solos, &c.
Canzonet—A piece, vocal or instrumental, of a flowing character.
Capriccioso—Capriciously, as to time.
Catch—A humorous vocal piece for several voices.
Cavatina—A graceful, simple air.
Coda—Tail; the end.
Con—With. *Con Amore*—With affection, lovingly. *Con Anima*—With soul, in a feeling manner. *Con Brio*—With animation. *Con Fuoco*—With fire. *Con Espressione*—With Expression. *Con Moto*—With movement. *Con Spirito*—With spirit. *Con Sordini* With dampers (piano); *i.e.* without pedal.
Crescendo—Gradually louder.

DA CAPO (D.C.) — From the beginning.
Decrescendo—Gradually softer.
Diminuendo—Decreasing as to tone.
Dolce—Sweetly, gently.
Doloroso—Dolorously, with an expression of pain.
Due Corde—Literally, two strings. The soft pedal (piano) to be released.

ENHARMONIC—Similar in pitch, but differing in name, as G♯ and A♭.
Ensemble—Together; *ensemble* playing, concerted playing.
Espressivo—Expressively.
Etude—A study; an exercise.
Extemporise—To create music on the inspiration of the moment.

FALSETTO—Head or feigned voice as opposed to natural or chest voice.
Fanfare—A trumpet tune; a flourish of trumpets.
Fantasia—A composition in free, fanciful style.
Fine—The end; used after a repeat (see text).
Forte, Fortissimo (*f*, *ff*)—Loud; very loud.
Forza, Con—With force.
Fugue—A composition in which parts do not all begin at once, but, as it were, follow each other successively.

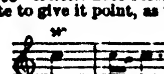
GAMUT—Old term for the scale.
Gavotte—A lively dance of French origin, popular in seventeenth and eighteenth centuries.
Giocoso—Humorously, jocosely.
Gioioso—Joyous, cheerful.
Giusto—Just, strict, as *Tempo Giusto*, in strict time.
Glee—A composition for voices, peculiar to England.
Glissando—The playing of several rapid scale notes successively, by sliding one finger along the white keys of the piano, instead of separately fingering each note.
Gondolied—A gondolier song.
Grandioso—Grandly.
Grave—Gravely, solemnly.
Grazioso, Con grazia—Gracefully.

HORNPIPE—An old English dance.

IMITATION—A species of fugue where the parts imitate each other.
Impetuoso—Impetuously.
Impromptu - Extempore, unpremeditated; a piece like an improvisation.
Intermezzo — Literally, intermediate; introduced between acts of an opera, &c.
Introit—A short anthem preceding the service of the Roman Catholic Church.

LANGSAM—Slowly.
Larghetto—Rather slow, in a broad style.
Largo—Slow and solemn.
Legato—Smooth, connected.
Leggiere—Easily, lightly, delicately.
Lento—Slow.
Lied—German term for a simple song.
L'istesso tempo—The same time; used where a change of time-signature occurs, to indicate that the length of the beat remains the same though represented by a different kind of note.
Loco—The place: after *8va*, to point out that the music is to be rendered in its proper octave, as written.

MA—But; as *Vivace ma non troppo*, lively, but not too much so.
Madrigal—An unaccompanied part song
Maestoso—With majesty or dignity.
Mano Destra (M.D.)—The right hand. *Mano Sinistra* (*M.S.*), the left hand.
Marcato—Marked, emphatic.
Marziale—In martia style.
Mazurka—A Polish dance, in triple time.
Meno—Less, as *Meno allegro*, less lively.
Mezzo—Medium, as *Mezzo forte*, moderately loud.
Minuet—An old French dance, in triple time.
Moderato—Moderate, as to pace.
Molto—Much, very, as *Molto allegro*, very lively.
Mordente—A little note before a principal note to give it point, as thus—



Written. Played.

Morendo — Dying away; gradually diminishing the tone.
Mosso—Moved, as *Più mosso*, more moved, quicker.
Moto—Movement, motion (see *Con moto*).

NOCTURNE—A composition of light and elegant character.
Non—Not; *Non troppo*, not too much.

OBBLIGATO—Indispensable; a part or accompaniment of essential importance.
Octet—A composition for eight instruments or voices.
Op. (for **Opus** or **Opera**)—A work; used to indicate the number of a composition in the order of its composer's works.

PASTORAL—A simple air, in $\frac{6}{8}$ time, of a rustic character.
Ped.—The sustaining, usually called the loud, pedal of the piano.
Perdendosi—Losing in sound, growing softer.
Pesante—Heavily, impressively.
Piano (*p*)—Softly.—**Pianissimo** (*pp*)—Very softly.
Più—More, as *Più allegro*, more lively.
Plainsong—The most ancient kind of ecclesiastical music.
Poco—A little, as *Poco a poco*, little by little.
Polonaise—The Polish national dance, in triple time.
Pomposo—Pompously.
Portamento—Gliding from note to note in singing.
Presto—Fast. **Prestissimo**—Very fast.

QUASI—Like, in the style of, as *Andante quasi allegretto*, Andante in the style of allegretto.
Quintet—A composition in five parts.

RALLENTANDO—Gradually slower.
Recitative—Musical declamation.
Rhapsody—A composition in a free style.
Risoluto—In a resolute manner.
Ritardando, Ritenuto—Retarding the speed.
Rubato—Literally, robbed: *Tempo Rubato*, a slight deviation to give more expression by retarding at one place and quickening at another; not in strict time.

SCHERZANDO—Playfully.
Scherzo—A lively, playful piece.
Sempre—Always, as *Sempre staccato*, always staccato.
Senza—Without.
Senza Sordini—Without dampers (piano), *i.e.* with pedal.
Sforzando, Sforzato (Sf.)—Forced, with great emphasis.
Smorzando—Gradually fading away.
Sostenuto—Sustained.
Sotto Voce—In a subdued tone.
Staccato—Short, detached (see text).
Stringendo—Hurrying on the speed.
Syncopation—Irregular or cross accents; binding the last note of a bar to the first note of the next; accented notes occurring in the unaccented part of a bar (see text: *Counterpoint*).

TARANTELLA—A Neapolitan dance in $\frac{6}{8}$ time.
Tempo—Time. *Tempo Primo*—the original pace (after Rallentando, etc.).
Tenuto (Ten.)—Hold for the full time.
Tremolo—Trembling; the rapid alternation of notes to produce a trembling effect.

UNA CORDA—One string; *i.e.* with the soft pedal.

VELOCE—Rapidly, swiftly.
Vibrato—With much vibration of tone.
Vivace—Lively, vivacious.
Volti Subito (V.S.)—Turn over quickly.

SHOPKEEPING & BUSINESS SYSTEMS

A GUIDE TO THE KEEPING OF SHOPS OF EVERY KIND AND SIZE

AND TO THE

UTILISATION OF TIME AND LABOUR-SAVING SYSTEMS IN BUSINESS MANAGEMENT

INCLUDING

Post Offices	**Bakers**	**Booksellers**	**Greengrocers**	**Toys and Games**
News Agents	**Butchers**	**Boots and Shoes**	**Ironmongers**	**Jewellers**
Picture Framers	**Drapers**	**Fishmongers**	**Pawnbrokers**	**Saddlers**
Tailors	**Grocers**	**Florists**	**Smallwares**	**Bicycle Shops**
Stationers	**Hosiers**	**Hairdressers**	**Tobacconists**	**Music Dealers**

DEALING ALSO WITH

COMMERCIAL TRAVELLERS, AND ALL OTHER CAREERS ASSOCIATED WITH SHOPKEEPING

AND WITH

PUBLICITY & ADVERTISING, THE CHIEF FACTORS IN COMMERCIAL SUCCESS

BY

D. N. DUNLOP, **Manager for Europe of the Westinghouse Companies' Publishing Department**
WAREHAM SMITH, **Advertising Manager of the "Daily Mail"; and other Authorities.**

THE BUSINESS OF SHOPKEEPING AND ITS BEGINNING

IN this and the subsequent chapters of the series, which, when completed, will form a handy, comprehensive, practical guide to Shop-Keeping, we shall confine ourselves to shops in the sense of "buildings or apartments in which goods, wares, drugs, etc., are sold by retail," and by shop-keeper we mean "Retail Trader, in distinction from a Merchant, or one who sells by wholesale." The shop of the craftsman or mechanic does not come within our scope.

It is astonishing how little may be learnt from books about the all-important subject of Shop-Keeping. It would appear that familiarity with such a common sight as a shop had bred a certain contempt for it.

An Unorganised Community. People have been in the habit from their cradle of frequenting shops, but have never chosen to be interested enough, nor have ever dared to be inquisitive enough, to enquire about the practice and method of shopkeeping. They have always got what they wanted and have cared nothing as to how it was kept. The shopkeeper, too, especially in the past, was invariably of a reserved, exclusive disposition, always too occupied in minding his own business literally to think of putting on record how he carried it on, and thus came to pass the anomaly that, in the literature of the "nation of shopkeepers," no place was found for the subject of keeping shops.

Yet what could be more truly British, and more really important, than the distributive industry of this country. It may be both interesting and useful to note that the exclusiveness just mentioned was only profitable to the shopkeepers individually. It was anything but beneficial to them as a community. It deprived them of adequate political expression, and prevented concerted action being taken for their benefit; such, for instance, as in the regulation of the internal economy of their establishments. For a century or more they were numerous enough to be very powerful, but, without a leader, and having no effective organisation, they were, until quite recently, about the most powerless section of the population, save, perhaps, that still more numerous class the shopkeepers' assistants—the would-be shopkeepers!

False Gentility. But not only did familiarity with shops dull the imagination in respect of shopkeeping, even to the entire exclusion of so important a subject from the literature of the country; it led people to form erroneous notions. The real cause of any falling off in the British distributive industry has been false gentility—the insane notion that there is something derogatory in trade as a career for respectable sons and daughters. Early in the eighteenth century—in the days of Pope—himself the son of a merchant—we know, on the authority of Sir Walter Besant,—that "the tradition of sending the younger sons into trade survived the practice. The younger sons of country gentry no longer sought apprenticeship and fortune in London.... It was considered beneath the dignity of a gentleman to sell anything, or to soil his fingers with any kind of trade, or to deal in any kind of commercial enterprise."

The earliest fortunes that were made in shopkeeping were taken out of the trade and invested in land, upon which the retired tradesmen lived. At first there were their sons and nephews to fill up the gaps in the business, which, despite changes, continued to prosper. By the time the eighteenth century was reached the number of shops had increased enormously, numerous openings were created, and it became necessary to recruit young men to fill these from somewhere.

The Decline in Shopkeeping. No more sons of country gentry were available, while the supply of the sons and nephews of the fortunate retired shopkeepers had become exhausted. Then it was that "the poor youths —those who had everything to gain, and who were already employed in some capacity in the

City—understood what was wanted. There were thousands of such young men; but there were but a few—there are never more than a few—who understood the first essentials of success—how to see and how to seize the opportunity." That these men were uneducated and vulgar we should expect, and a book published in 1800, giving the parentage and history of the City Fathers of that time, abundantly proves it.

If that could be the case two hundred years ago, in the early history of shops, how much more so has it become since! For, during the past 60 years, the number of shops has increased more than it had done during the preceding 500 years. It is obvious, therefore, that the "science and art" of shopkeeping had not advanced in anything like the same proportion to the number of shopkeepers, solely because the trade had not attracted the best educated, the ablest and the noblest of the young men of the country. So that another extraordinary anomaly now existed: this typically British and quite indispensable industry was left almost entirely to those young men who had the least educational and social advantages.

Its Failure to attract. History, then, teaches that trade, as far as shopkeeping is concerned, has suffered, not so much from defective education as from failure to enlist the services of the educated.

Granted, however, that the trade has been carried on by shopkeepers of humble origin, of little or no education, the fact proves only that a better class of men would trade in a better way. Shopkeeping, in these days of acute competition, when the "multiple" shop vies with the limited liability company in squeezing the "small man" out of the field, requires the very best of the youth and manhood of the nation.

Shopkeeping is an indispensable trade that constantly grows in importance, and it offers, therefore, an excellent and lucrative career to capable men and women. There are urgently wanted—to quote Mr. F. F. Bridgewater—"live young men of ideas, who can think for themselves; we must stop sending the best of them to work like machines from ten to four . . . in Banks and Insurance Offices where they have no hope of becoming their own masters. If they earn 30s. a week, at least they can wear a top hat and black coat and call themselves professional men. The banks and insurance companies make a vast profit from this state of affairs. In effect, the bank and insurance clerk pays £2 or £3 a week out of his pocket for his pseudo-professional standing. . . . When we cease to decry the trade which butters our bread, when we have a middle-class which is less steeped in out-of-date conventionality, then we shall find Great Britain doing much better in the commercial warfare which is her lot."

Facilities for Acquiring Knowledge. Shopkeeping, it will thus be seen, affords an excellent scope for healthy young men and young women of energy, education and a fair share of sound common sense, and the problem, therefore, is how to induce the well-educated and good-mannered young men and maidens to adopt shopkeeping as a career.

One important step to this desirable end is the recent welcome activity in the direction of providing facilities for those who are already engaged in trade to acquire the technical education, so essential to their own advancement, which they should have received before entering business. To acquire the knowledge of a trade, which is essential to efficient salesmanship and successful shopkeeping, a period of apprenticeship is absolutely necessary, and it is during this time that the learner is most likely to appreciate the value of technical instruction, inasmuch as he would then be in a position to apply the theories in his daily work, and thus enhance his enjoyment in the performance of his duties.

There are at present very few branches of shopkeeping without a trade organ, and no enterprising shopkeeper can afford to do without the trade paper, which keeps him informed of the state of the market, and of what transpires in the trade outside his own establishment. The Drapery and Grocery trades are particularly well catered for; the Ironmongery, Hardware, Boot and Shoe Leather, Chemists and Druggists, Fruiterers, and Tailoring trades are also well supported.

An Excellent Field for Investment. It is also, with efficient management, an excellent field for investment. The "small man," the widow, and other peculiarly situated people who are possessed of a limited capital may confidently turn their attention to shopkeeping on a small scale if they use judgment in their selection of locality and study the needs of the population. The greatest care must be exercised, in taking the premises, not to yield to exorbitant exactions as to rent and agreement; the employment of a reliable solicitor is desirable in even the most seemingly trifling circumstances, lest there may lurk in some clause an error or omission capable of endless trouble and litigation afterwards. In most businesses on this small scale it should be borne in mind that it is usually the rent that kills. Care should be taken, also, not to start in a new thoroughfare or locality, unless the capital is large enough to ensure against the almost certain loss which must be faced during the first year or so. One has only to consider the number of times a shop in a new Arcade or on a new Terrace usually changes hands before it yields a profit over and above the establishment charges to appreciate the value of this hint.

Essentials for a Good Choice. The choice of a trade mainly depends upon three things—the taste or qualifications of the candidate, the amount of the capital at his disposal, and the needs of the neighbourhood. The man or woman who contemplates the opening of "a little shop" without previous experience is limited in the choice of trade to enter; and while a certain amount of knowledge of any trade is highly desirable before attempting to conduct it, there are a few which may be mastered so easily that no previous

knowledge of them is essential. It is well to study the possibilities from every standpoint when selecting the site, especially if the start be ventured in a new district, in which case everything should be done with a view to the future. Care must be taken to avoid any reckless or unnecessary expenditure to "push the trade" beyond the capacity of the district, which is always a temptation if progress be slow and the returns only moderate.

The Site. The most commanding site available should be selected, so that the most may be made of a good display. Judging by the stale and dusty appearance of the window in most small shops not owned by enterprising capitalists or the companies, window-dressing is sadly neglected, though it be one of the finest arts, requiring all the genius and the skill of the painter and draughtsman combined to practise it in its perfection. No business is so small that it would not profit by having great attention paid to its window-display. From sheer force of habit, involuntarily and almost unconsciously, we look at shop windows and take in the contents at a glance, but only the effectively-dressed or displayed windows compel the closer inspection which usually leads to a purchase. But it is not sufficient nowadays to make an effective display for universal admiration merely, but a free and judicious use of the ticket-writer's art must be made to represent value in a tempting and convincing fashion. The tickets must be neither too big nor yet too full—they must be clean, the letters and figures must be bold and neat, and the articles to which they are affixed must be the perfection of their kind—clean, fresh, and unblemished. The newsagent, the tobacconist, or the fruit shop situated at or near the terminus of a railway or a tramway, or at or near the corner of a busy thoroughfare, or the confectioner with an appetising, wholesome, and inexpensive display of sandwiches, porridge and stewed fruit, near a workshop where many hands are employed, is assured of a flourishing time if he takes care of his window. "Take care of your window and your window will take care of your shop," may well be accepted as the motto of shopkeeping.

Good Management. Having chosen the line of business and settled the important matter of locality and premises, all is plain sailing if due care and cautiousness, judiciously directed energy, and the liberal exercise of common sense are given free play. However small the concern may be, too much care cannot be given to the matter of keeping an account of every payment made and of the takings every day; and the smaller the business the more imperative it is to insist upon cash for every purchase, never yielding to the habitual temptation to give credit, however small.

No elaborate system of book-keeping is needed. Two books at most are ample—a day-book and a cash-book. The shop and everything in it should at all times be scrupulously clean, and the habit of pleasing the customers from the first should be assiduously cultivated No business can succeed without advertisement, and no advertisement is so effective as the treating of customers in such a way as to cause them to repeat, and to continue to repeat, their custom. And all the main essentials to this end are the free gifts of Nature. It is incumbent on all shopkeepers to be careful that such talents as they have shall not be hid. Without them, salesmanship is well-nigh impossible, and efficient salesmanship is the concentrated essence of all the qualifications needful in successful shopkeeping. According to one modern authority, "health, sincerity, ability, industry and knowledge" are the five great essentials of good salesmanship. Upon these things depends the success of shopkeeping, whatever the line of business may be.

Kindred Trades. We are concerned with shopkeeping generally, and with such qualifications as are common to all classes of trade. Many trades are kindred to one another. The most comprehensive, probably, is the drapery trade, which includes, besides linen and woollen products, a large variety of other textile goods, such as silks, satins—which are specialised by silk mercers—hosiery, lace, ribbons, haberdashery and fancy goods. The grocer finds it quite convenient to deal in provisions, dairy and garden produce, meat and poultry. The ironmonger naturally supplies oils and colours, hardware and machinery. The stationer is expected to supply books, newspapers and fancy goods, while chemists and druggists frequently encroach upon some of the grocer's specialities. The newsvendor is generally also a confectioner, stationer, tobacconist and toy-dealer. It is fast becoming the rule for the largest drapery establishments to emulate the mammoth stores by including everything saleable, or, at any rate, to provide anything required for furnishing the house, and for clothing as well as feeding, doctoring, and recreating the persons living in it.

Shopkeeping Law. Shopkeepers are expected to acquaint themselves with the provisions of many Acts affecting their trade, notably the Sale of Food and Drugs Acts of 1875, 1879, and 1900; the Margarine Act, 1887; the Merchandise Marks Act, 1887; and the Shop Hours Regulation Act, 1892. The last of these provides that no young person shall be employed "*in or about a shop for a* longer period than 74 hours, including meal-times, in any one week," and imposes a fine not exceeding £1 for every person so employed. Owing to a defect revealed in this Act by the case of Hammond *v.* Pulsford, another Act was passed to remedy it by enacting that a notice is to be exhibited by the employer in a conspicuous place, stating the number of hours in the week during which a young person may be lawfully employed in the shop. Any employer who fails to exhibit this notice may be fined £2.

Among more recent Acts are the Shop Hours Act of 1904, enacting that an order for the early closing of shops may be made by a local authority either throughout the area of the

local authority or in any specified part thereof. The closing of shops on Sundays, however, is left wholly to the operation of the Sunday Observance Act of 1667. The Employment of Children Act, 1903, the Weights and Measures Acts, the Sale of Food and Drugs Acts, and many others, also affect the shopkeeper, and he should not fail to make himself acquainted with their meaning.

Capital to begin with. The question of the amount of capital at disposal is a most important one. As the yearly list of failures only too amply proves, insufficient capital is the most prolific source of insolvency. Whereas a small shop—a newsagency, tobacconist's, stationery, confectionery, or a "little general"—may, with extreme care and economy, be started with any sum from £20 to £100, a shop in the grocery, drapery, ironmongery, or any trade specially allied to these, cannot hope for success if the initial capital is less than £500. There may be a few instances where special ability, with the assistance or indulgence of the wholesale trade, has succeeded in building up a business with a smaller capital, but it is a risky speculation at best when, in counting the cost, a liberal provision is not made for the ready cash for stock-in-trade, and, also, for establishment charges, such as rent, rates, taxes, insurances, labour and incidentals. All these must be regularly met, whether there be a brisk sale or not. It is essential that stock should be promptly paid for, so as to secure the increased discount for cash, however trifling. Nothing could be more instinct with failure for the beginner in shopkeeping than a false start in this respect.

Shop System. Time-saving and labour-saving appliances, while essential to a business of any respectable dimensions, are hardly profitable in the small business, where the trade does not demand their aid and the capital for working purposes is limited. "Necessity is the mother of invention," and inventions are only profitable when the growth of the business necessitates their use. In a huge establishment, the simple, toy-like, but perfectly efficient overhead cash-railway system is invaluable in many ways; it enables the salesman during the few seconds the ball is rolling to and from the desk to introduce another "line," or to attend to other customers. Moreover, the counter and the customers are not left unattended, and the assistants are spared the fatigue of frequent running and dodging about. In a large provision business the bacon-cutting machine and cold storage appliances are indispensable. In establishments where the living-in system is in vogue, large sums are profitably invested in making the culinary department replete with the latest cooking-appliances, such as kitcheners, bread-slicers, and knife-cleaners. Equally indispensable to the efficient conduct of business are all the products of electrical science—the lift, the telephone, the electric-bell, and the indicator.

Enough has been said to show what an enormous scope for talent, energy, and enterprise is offered in a career of shopkeeping. And, whereas no vocation affords so many temptations to dishonesty or sharp practice, the fact is proved by experience that in no walk of life is the old adage that "Honesty is the best policy" more forcibly verified.

To be continued.

THE CHOICE OF A SHOPKEEPING CAREER.

THE following list details briefly the conditions usually prevailing in the chief shopkeeping trades. It has been carefully compiled from authoritative sources, and the figures given are those that seem to be the more usual throughout the United Kingdom. From most shopkeeping trades the system of indenturing apprentices has almost disappeared. The sum recommended as capital is the minimum upon which a start can be made with any prospect of success.

Baker and Confectioner. Regular apprenticeship not general. Lads are engaged at about 6*s.* per week; journeymen bakers earn from 25*s.* to 35*s.*, foremen rising higher. Capital required to start a bakery equipped with machinery, £150 and upwards.

Barbers. In ordinary barbering and hairdressing apprenticeship varies in length from two to seven years. Boys receive about 2*s.* 6*d.* per week to begin; assistants earn from 21*s.* to 32*s.* plus commissions on articles sold. Business may easily be started on £50 capital. [See also HAIRDRESSERS.]

Booksellers. Conditions similar to those for stationers, but double capital required.

Boots and Shoes. Practical apprenticeship five years, and wages 5*s.* to 14*s.*; journeymen earn from 25*s.* to 35*s.* Girls usually engaged as messenger girls at 2*s.* 6*d.* and rise to 20*s.* or 25*s.* per week. Capital required to start, £120.

Butchers. Errand boy engaged at about 5*s.* weekly and left to work his way up. An assistant salesman going the rounds with pony and trap receives 30*s.* to 40*s.*; shop salesman usually a little less. Cash business may be started on £50; credit business on £150 to £200.

Chemists and Druggists. Premiums of £20 to £100 required in apprenticing to high-class chemists in England. Such apprentices live indoors. Ordinary unindentured outdoors. Apprenticeship wages, 4*s.*, 5*s.*, 6*s.*, 7*s.* weekly; four years' apprenticeship is the rule in both cases. Assistants' wages, 20*s.* to 30*s.* per week for unqualified men, and 30*s.* to 50*s.* for qualified assistants. The best positions are as dispensers in public institutions, or as employees of the large drug stores. Capital required to start Pharmacy, £300.

China and Earthenware. Apprenticeship is unusual, message boys or girls beginning respectively at 4*s.* and 2*s.* 6*d.* per week, rising by experience to be selling assistants, and earning anything up to 30*s.*, according to ability. Business may be started on £100.

Drapers. Apprenticeships usually three to four years and wages 6*s*., 7*s*., 8*s*., 9*s*., per week; assistants make 16*s*. to 30*s*. Living-in apprentices receive no wages, but may receive small commissions on sales during the latter half of term. Living-in assistants receive £20 to £30 a year. Female apprentices not common; female assistants receive 8*s*. to 20*s*. a week, or if living in up to £15 per year. Capital required for small drapery business, £200. Capital should be turned over four times a year.

Furniture Dealers. In the practical side, departmentalism has nearly killed the general apprenticeship system. Where apprentices are taken time is usually for five years, beginning at 4*s*. or 5*s*. and rising to 8*s*. or 10*s*. Journeymen workers earn 7*d*. to 11*d*. an hour. Salesmen frequently begin as message boys at 5*s*. a week and work their way up. Assistant salesmen begin at about 20*s*. to 25*s*. a week, and may rise to several hundreds a year in best shops. Trade usually allied to general house furnishing. Modest business may be set up on £100—£200, but present tendency is towards hire-purchase trading, which requires much more capital.

Grocers. The apprenticeship system is becoming less usual, but where it exists it is from three to four years. Wages, 6*s*., 8*s*., 10*s*., 12*s*. Assistants earn from 17*s*. to 28*s*. Capital required, £170 to £200. Stock should be turned over eight times a year.

Hairdressers. As distinct from ordinary barbers, hairdressers serve no apprenticeship, but may receive instruction in one of the hairdressers' schools in London and the provincial cities. Salaries for artists in ladies' hairdressing are usually from two to three guineas a week, plus commission. [See also BARBERS.]

Ironmongers. Apprenticeship usually four years, and wages, 4*s*., 5*s*., 6*s*., 7*s*. Assistants earn 20*s*. to 40*s*. Capital required to start general ironmongery business, £600. Stock should be turned over twice a year.

Jewellers. A premium of £50 to £100 is usually paid when a youth enters as apprentice, the premium being returned in the form of wages during service. Apprenticeship terminates at the ages of 21. A journeyman jeweller earns from 27*s*. to 50*s*. per week. The best working jewellers in London, the seat of the English trade, are foreigners—French, Belgian, Swiss. Capital required to start business with small stock, £500. Good men have stock on consignment from wholesale houses or manufacturers. In the mixed watch-making and jewelling trade of the provinces a seven years apprenticeship is common, wages beginning at 5*s*. and rising to 12*s*.

Milliners. Two years' apprenticeship and no wages paid. A premium of £10 to £20 is often required. Assistants earn from £10 to £30 a year. Capital required to start, £100; more if extended credit is given.

Oil and Colourmen. In the ordinary oil and colour shop apprenticeship is unusual. Boys begin at about 4*s*. or 5*s*., and in about four years are worth 15*s*. a week, rising as high as 26*s*. or 28*s*. The proprietorship of a business may be attempted with £100 capital.

Opticians. One of the few businesses which are not overcrowded, and where a competence is fairly certain to those electing to follow it. Employers prefer technically trained youths instead of apprentices. Instruction in optics is conveyed at Northampton Institute, London. Assistants easily earn 40*s*. to 60*s*. a week, and managers rise as high as £500 a year. A sight-testing optician may begin business on £250—£350 capital, but to embrace the trade in all its branches £1000 is necessary.

Photographers. Apprenticeship prevails, but not common. Usual length four years, beginning at 3*s*. or 4*s*. a week and rising to 10*s*. Assistant operators earn 20*s*. to 50*s*. Business is often attempted with success on a very few pounds, but to equip a studio properly demands £100 to £200.

Pawnbrokers. Apprenticeship practically unknown. Warehouse boys usually live in, and receive, in addition to board and lodging, £6 or £8 a year. Assistants earn 30*s*. a week; managers in first-class establishments from £250 to £300 a year. Many who enter the trade leave it for other vocations. A merchant business is usually incorporated with pawnbroking proper. Capital necessary, £2,000.

Plumbers. Usually serve five years' apprenticeship, beginning at 4*s*. per week and reaching 10*s*. Journeymen earn from 7*d*. to 11*d*. an hour. Capital required £100, to £200.

Painters. Usual apprenticeship five years. Wages, 6*s*., 7*s*., 8*s*., 10*s*., 12*s*. Journeymen painters earn from 25*s*. to 35*s*. Capital required to start as a painter and paperhanger, £60.

Saddlers. Apprenticeship for practical saddler, seven years; wages, 5*s*., rising to 12*s*. Shorter apprenticeships are becoming more common. Journeyman saddler earns from 25*s*. to 35*s*. per week. A small saddlery business may be started on £100 capital. More is often required on account of the long credit frequently prevailing, and the practice of bribing coachmen and grooms to secure and retain wealthy customers is unfortunately common.

Stationers. Usual apprenticeship five years, and wages, 4*s*. 6*d*., 6*s*., 7*s*., 8*s*., 10*s*. Assistants' wages, 18*s*. to 30*s*. Capital required to start, £100 to £200. Stock should be turned over four times a year.

Tailors. Working tailor's apprentice serves five years, earning 4*s*., 5*s*., 6*s*., 7*s*., 8*s*. 6*d*. a week; journeymen tailor earns 30*s*. to 35*s*. a week, but has much idle time. Capital required to start business holding some stock, £80. Shopmen, as distinct from practical tailors, earn 17*s*. to 30*s*. a week.

Watchmakers. Terms of apprenticeship as under Jewellers, but tendency is to reduce the time served. The two trades are usually allied. Technical instruction in horology given at Horological Institute, London, both to attending students and to learners by correspondence. Wages and other particulars as under JEWELLERS.

SHORTHAND AND TYPEWRITING

THE FUNDAMENTAL QUALIFICATIONS IN COUNTLESS SITUATIONS

BEING

SHORTHAND TAUGHT BY SIR ISAAC PITMAN & SONS ON THE TWENTIETH CENTURY PLAN

AND A PRACTICAL COURSE COVERING

TYPEWRITING, WITH THE WORKING AND MANAGEMENT OF ALL THE CHIEF MACHINES

ADVANTAGES OF SHORTHAND AND THE PITMAN SYSTEM

ALTHOUGH the art of shorthand is of considerable antiquity, it has only within recent years come into general use in this country. There is abundant evidence, however, that it stands to-day in the first rank of subjects of general utility, and its students and practitioners are numbered in millions.

This great development in the use of the art followed, as all the world knows, from the labours of Sir Isaac Pitman in the invention and perfection of the system associated with his name, and from his lifelong efforts in popularising an art of such universal service in modern life.

The Pitman System. Briefly stated the two chief causes of the present position of shorthand are these:

1. The Pitman system of shorthand is founded on a philosophical basis, approved by Max Müller and other eminent authorities on the representation of language in writing, while, as the result of its use by a host of able shorthand writers in every field of work, the system has been developed on lines of practical usefulness to a far greater extent than any other method.

2. Ever since the advantages of shorthand were fully demonstrated, there has been a progressively increasing demand for the services which this useful art in the hands of competent practitioners can render, particularly in association with literary and commercial enterprise of every description. There are now very few positions involving any considerable use of the pen, in which it is not one of the conditions that the worker shall have a knowledge of shorthand, and therefore the cultivation of the art has become general—it might almost be said compulsory—among all those who seek to enter professional or business life.

The student who takes up the study of Pitman's shorthand through the lessons presented in these pages will do so from the latest and most successful presentation of the system, namely that to which the distinctive title of "Twentieth Century" has been given. The question the novice will naturally put is, "Can I learn shorthand?" Assuming that he has had a fairly good elementary education, and is willing to exercise the necessary perseverance, he can unquestionably do so.

The "Alphabet of Nature." The task before him is comparatively simple, namely, that of mastering the use of a set of symbols for representing the English language in a briefer and much more scientific fashion than the ordinary longhand with which he is familiar. When he has thoroughly learned the characters employed and their proper use, practice in shorthand writing and reading will bring proficiency.

By the employment of what has been termed the "alphabet of nature" the English language can be recorded in Pitman's Shorthand with one-sixth of the trouble and time which longhand requires, and with the adoption of the systematised methods of abbreviation developed in the briefest style, this system of shorthand can be written with the speed of the most rapid distinct articulation.

Sound Writing. The name which Sir Isaac Pitman gave to his system was that of Phonography—a term derived from two Greek words meaning "sound writing"—because its notation is based on the sounds of spoken language. The student must, therefore, bear in mind from the outset that in writing shorthand he must represent spoken sounds only, and these by the appropriate signs provided in the system. For example, if he wishes to write the word *knee* (commonly spelt with four letters, though made up of only two sounds), he needs to use but two phonographic signs, namely, that for the consonant *n* and that for the vowel . *ē*, thus, *knee*. To spell in this fashion a mental analysis of the sounds of words must be made, but this process is very easily acquired, and is soon exercised without conscious effort.

In doing the work prescribed in the present course of lessons, the student should use a pen and ruled paper having a smooth surface. The consonants should be written about one-sixth of an inch long, as in these pages. The student should hold his pen as for longhand writing, but the elbow should be turned out, so that the letter *b* can be struck with ease. He should hold the pen lightly. The wrist must not be allowed to rest upon the note-book or desk. In order to secure the greatest freedom of movement, the middle of the fore-arm should rest on the edge of the desk. The writer should sit in front of his work, and should have the paper or note-book parallel with the edge of the desk or table. For shorthand writing the nib employed should not be too stiff, but, as the thick and thin characters of Phonography need to be made quite distinctive, it must have a sufficiently fine point for this purpose.

TABLE OF CONSONANTS.

Letter.	Character.	Name.	As in	
P		pee	ro*p*e	*p*ost
B		bee	ro*b*e	*b*oast
T		tee	fa*t*e	*t*ip
D		dee	fa*d*e	*d*ip
CH		chay	e*tch*	*ch*est
J		jay	e*dg*e	*j*est
K		kay	lee*k*	*c*ane
G		gay	lea*gue*	*g*ain
F		ef	sa*f*e	*f*at
V		vee	sa*v*e	*v*at
TH		ith	wrea*th*	*th*igh
TH		thee	wrea*the*	*th*y
S		ess	hi*ss*	*s*eal
Z		zee	hi*s*	*z*eal
SH		ish	vi*c*ious	*sh*e
ZH		zhee	vi*s*ion	trea*s*ure
M		em	see*m*	*m*et
N		en	see*n*	*n*et
NG		ing	lo*ng*	a*n*ger
L	up	el	fa*ll*	*l*ight
R	down up	ar, ray	fo*r*	*r*ight
W	up	way	a*w*ay	*w*et
Y	up	yay	a*y*ah	*y*et
H	down up	hay	ad*h*ere	*h*igh

The Consonants. For the representation of words in shorthand the familiar division of letters into consonants and vowels is made, but with this difference, that the Pitman alphabet provides a sign for each of the thirty-six broad typical sounds of the English language and assigns to each a definite sign, which is used invariably to represent that particular sound.

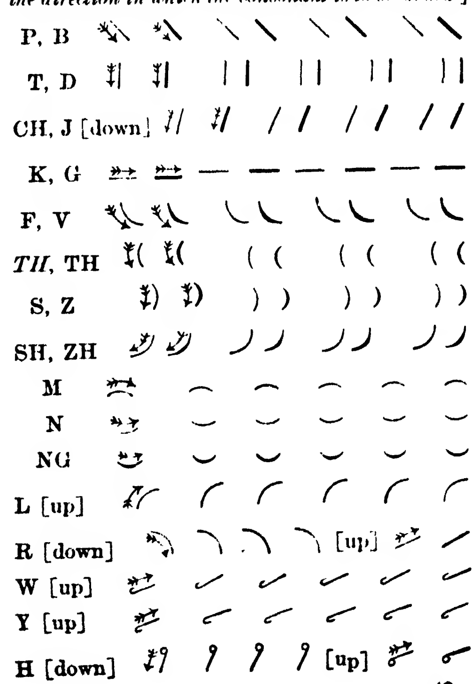
In the ordinary longhand alphabet there are twenty-six letters only, with the result that some of them represent several sounds, and thus occasion difficulties in spelling which do not arise in the use of a complete phonetic method of notation such as we have in Phonography. The consonant signs in the Pitman system number twenty-four (represented by geometrical strokes) and the vowel signs twelve (represented by dots and dashes). Every syllable or word is made up of one or more consonants and one or more vowels. For example, the consonant *p* standing by itself indicates a sound only, but if a vowel is added, thus , we have the word *pay* represented.

How to Memorise the Alphabet. In this lesson the student is introduced to the consonants only. He is required to commit to memory the consonant sounds, and to learn to write them with facility. In order to accomplish this, he must make a careful study of the table, so that he may understand thoroughly what the characters represent, and he must then memorize them *by the names given to them*. This can be best accomplished by pronouncing aloud the names of the consonants when writing the exercise. The student should not take the whole list at once, but should attack it in sections; first the eight straight characters, then the next eight curved characters, and then the final ten signs.

The first sixteen consonants form pairs; thus, *p* and *b*; *t* and *d*; *ch* and *j*; *k* and *g*; *f* and *v*; *th* and th; *s* and *z*; *sh* and *zh*. The articulations in these pairs are the same, but the sound is light in the first and heavy in the second consonant of each pair. Each pair of consonants is represented by similar strokes, but that chosen for the second is written *thick*, instead of *thin*; as *p*, *b*, *t*, *d*, *f*, *v*, etc. We have, therefore, a *light sign* for the *light sound*, and a *heavy sign* for the *heavy sound*. Thick strokes are never written upward. The consonants *chay* and *ray* are somewhat similar in appearance. It is impossible, however, to mistake one for the other, inasmuch as *chay* is always written DOWN, while *ray* is always written UP; thus *chay*, *ray*.

EXERCISE.

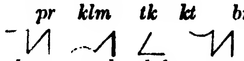
[*To be written by the Student. The arrow shows the direction in which the consonant is to be struck.*]



How to Make the Characters. In order to become a neat and graceful writer of shorthand, the student must zealously observe the rule of "drawing" the characters for some time, because unless he does he cannot become a good writer of the system. He should not be discouraged if at first he cannot make the characters "as fair as print." Constant practice and observance of the rule of slow and careful writing will soon enable him to do that.

Having thoroughly mastered the table of consonants, and acquired the ability to write any character without hesitation, the student will proceed to the joining of consonants, a process which demands careful work at the outset, and a strict adherence to the rule of drawing the characters. An important rule to be remembered is: "Observe the angles." In combinations like

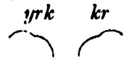
rr rp pr klm tk kt brbr drt



ktrt mrd ch k ntrt

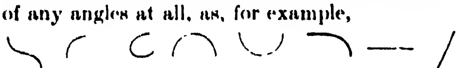
etc., the angles are, of course, easy enough to make; but in combinations such as

jnr nr fr yrk kr lr rk rm

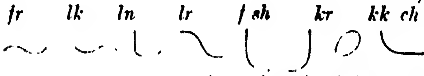


mr lm

etc., if the student is not from the first very careful in making the angles, he will find later on that he cannot read what he has written without a great deal of trouble. Of course, there are some combinations which do not admit of any angles at all, as, for example,



fr lk ln lr f sh kr kk ch ch

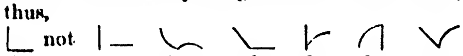


mn nm tn rf tf t sh l sh fk

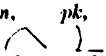
etc., all of which must be written with a single inflection of the pen.

All the examples given in this lesson should be carefully copied out, and the following rules mastered.

Rules for Consonants. Consonants when joined should be written without taking the pen from the paper, the beginning of the second consonant joining the end of the first; thus,

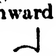


tk, not *fm, pk, tl, lt, pl,*



lp, sk.

Consonants when joined are written in the same direction as when standing alone, up strokes being always written upward, and down strokes downward; thus,

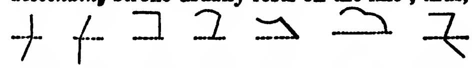
 *mt,* not 

L and *sh,* however, when joined to other strokes, may be written either upward or downward, under rules which will be explained later. The following are examples of the joining of these consonants:

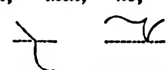
lm, . lm, lk, lk, l ng, sh f, sh m,

sh l, l sh.

In a combination of consonants, the first *descending* stroke usually rests on the line; thus,

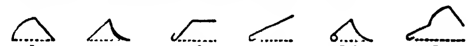


t ch, ch t, kt, mch, nb, mr, k ch p,

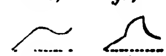


ptf, m n th l.

An *ascending* stroke beginning a combination should commence on the line; thus,

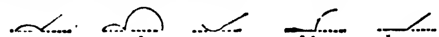


lp, rr, wk, yr, hf, ylp,

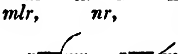


rmn, rlv.

A horizontal stroke followed by an ascending stroke is written on the lin thus,

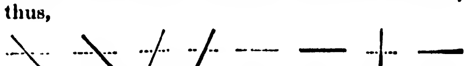


mr, mlr, nr, kl, kr,

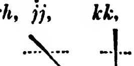


gl, kw.

When a straight consonant is repeated, there must be no break between the two letters; thus,

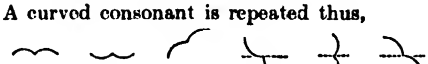


pp, bb, ch ch, jj, kk, gg, td, kg,



bp, dt.

A curved consonant is repeated thus,



mm, nn, ll, ff, ss, rr.

As already pointed out, *chay* is always a downstroke and *ray* always an upstroke; moreover, when *ch* and *r* stand alone, *ch* slopes a little from the perpendicular, and *r* slopes a little from the horizontal; thus,  *ch,*  *r.* The stroke naturally takes these slopes when struck downward and upward respectively.

When *ch* and *r* are joined to other strokes, they are distinguished by the direction of the stroke, and the amount of slope is of no importance; thus,

p ch, pr, ch t, rt, ch n, m ch, mr.

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To be continued

MATERIALS AND STRUCTURES

THE NATURE AND STRENGTH OF MATERIALS AND THE STABILITY OF STRUCTURES

A CAREFUL CONSIDERATION

OF THE CHIEF MATERIALS OF THE GREAT CREATIVE INDUSTRIES

COMPRISING A TREATISE ON THE PROPERTIES OF

Metals	**Cements**	**Rubber**	**Alcohol**	**Resin**
Timbers	**Slate**	**Gutta-Percha**	**Asbestos**	**Sands**
Stones	**Leather**	**Glue**	**Shellac**	**Sulphur**
Limes	**Bricks**	**Oils and Fats**	**Petroleum**	**Wax**
Concretes	**Glass**	**Mica**	**Pitch**	**Turpentine**

AND OTHER MATERIALS USED IN ENGINEERING, BUILDING, AND THE TEXTILE TRADES

BY

HENRY ADAMS, Thirty-five years Professor of Engineering at the City of London College, Examiner for the Board of Education and the Society of Architects.

THE CHARACTERISTICS AND PROPERTIES OF TIMBERS

By Professor Henry Adams

WOOD is, perhaps, the most widely diffused, and the most generally useful, constructive material in existence. From prehistoric times it has entered more or less into the construction of every human habitation, and it therefore forms the most fitting subject for our first consideration.

All trees are divided by botanists into three classes—*Exogens*, or outward growers; *Endogens*, or inward growers; and *Acrogens*, or summit growers—according to the relative position in which the new material for increasing the substance of the tree is added—whether towards the outside, the inside, or the top. Typical trees of each class would be the oak, the palm, and the tree-fern, and the inverse order would give approximately the historical order of their development in the course of Nature.

The Most Useful Class of Timber. The *exogenous* class is the latest and most highly developed product, and the most useful. It is this class which furnishes the timber in general use for construction, the term "timber" including all varieties of wood which, when felled and seasoned, are suitable for building purposes, and, generally speaking, for cabinet work also. An examination of a few sections will show the typical construction, and, while every variety shows some difference in detail, it will be seen that they all have certain features in common.

If the stem of an exogenous tree be cut across, it will be found to exhibit a number of nearly concentric rings, more or less distinct; and, in certain cases, radial lines intersecting them. These rings represent the annual growth of the tree which takes place just under the bark. Each ring consists of bundles of woody fibre or vascular tissue, in the form of long tapering tubes, interlaced, and breaking joint with each other, having a small portion of cellular tissue at intervals. Towards the outer edge of each ring the woody fibre is harder, more compact, and of a darker colour than the remaining portion.

The Age-marks of a Tree. The radial lines consist of thin, hard vertical plates formed entirely of cellular tissue, known to botanists as "medullary rays," and to carpenters as "silver grain." Figure **1** shows the woody fibre as seen in a magnified longitudinal section; **2** the cellular tissue, and **3** a typical section of the stem of a young tree, *a* being the woody fibre, *b* the pith, *c* the medullary rays, and *d* the bark, the three latter consisting of cellular tissue and enclosing the woody fibre in wedge-shaped portions. As the tree advances in age, the rings and rays become more irregular, the growth being more vigorous on the sunny side, causing distortion. As a rule, one fresh ring is added each year, so that the age of a tree may be known when it is cut down by counting the number of rings, but the rings vary in width according to the vigour of the growth during the season. In some trees, such as pitch pine, they are very uniform, while in others such as oak [**4**] they are very irregular.

When the trees are grown closely together as in a forest they are always straighter and taller as a result of their effort to surmount their fellows, and obtain all possible light and air. When grown singly they make handsomer trees, but have more branches, and therefore knots, and become more irregular. Let us glance at the means by which the growth takes place.

The Growth of a Tree. The roots absorb moisture from the soil, which, in the form of a watery fluid called the *common sap*, rises through the fibres of the last deposited annular ring, traversing all the branches and leaf stalks until it reaches the leaves; there it undergoes some change by the absorption of carbonic acid from the air. It then travels downwards again in the form of *proper sap* just underneath the bark, which is expanded by the accession of moisture, and in the cavity so formed a new layer of material is deposited which gradually hardens, and forms a new annular ring which consists

practically of cellulose ($C_6H_{10}O_5$). The part of the wood next the bark is called *sap-wood*, because it contains more or less unaltered sap, and is not only softer, but more liable to decay than the heart-wood, which is drier and more compressed.

Timber trees may be divided into two great classes—*coniferous* trees or pine-wood, and *non-coniferous* or leaf-wood. The first class contains such trees as pine, fir, larch, cowrie, or kauri, yew, cedar, etc., and the second class such as oak, beech, alder, plane, sycamore, chestnut, ash, elm, mahogany, teak, walnut, box, etc.

The Best Period for Felling. If a tree is felled too young the wood will be comparatively soft and liable to decay, while, if left too long, the wood will have become brittle, and decay at the heart will generally have commenced. If felled at maturity the greatest uniformity of texture will be found throughout, and, therefore, the greatest value will be obtained. Only those trunks or branches which reach six inches or more in diameter are reckoned as timber.

The best period for felling is when the vegetative powers are at rest, either midsummer or midwinter in most cases, but in oak trees it is found that the bark may be stripped in the spring, and the tree felled after the new leaves have been put forth and died, thus providing the best condition of the bark for use in tanning leather, and the best condition of the timber for structural purposes.

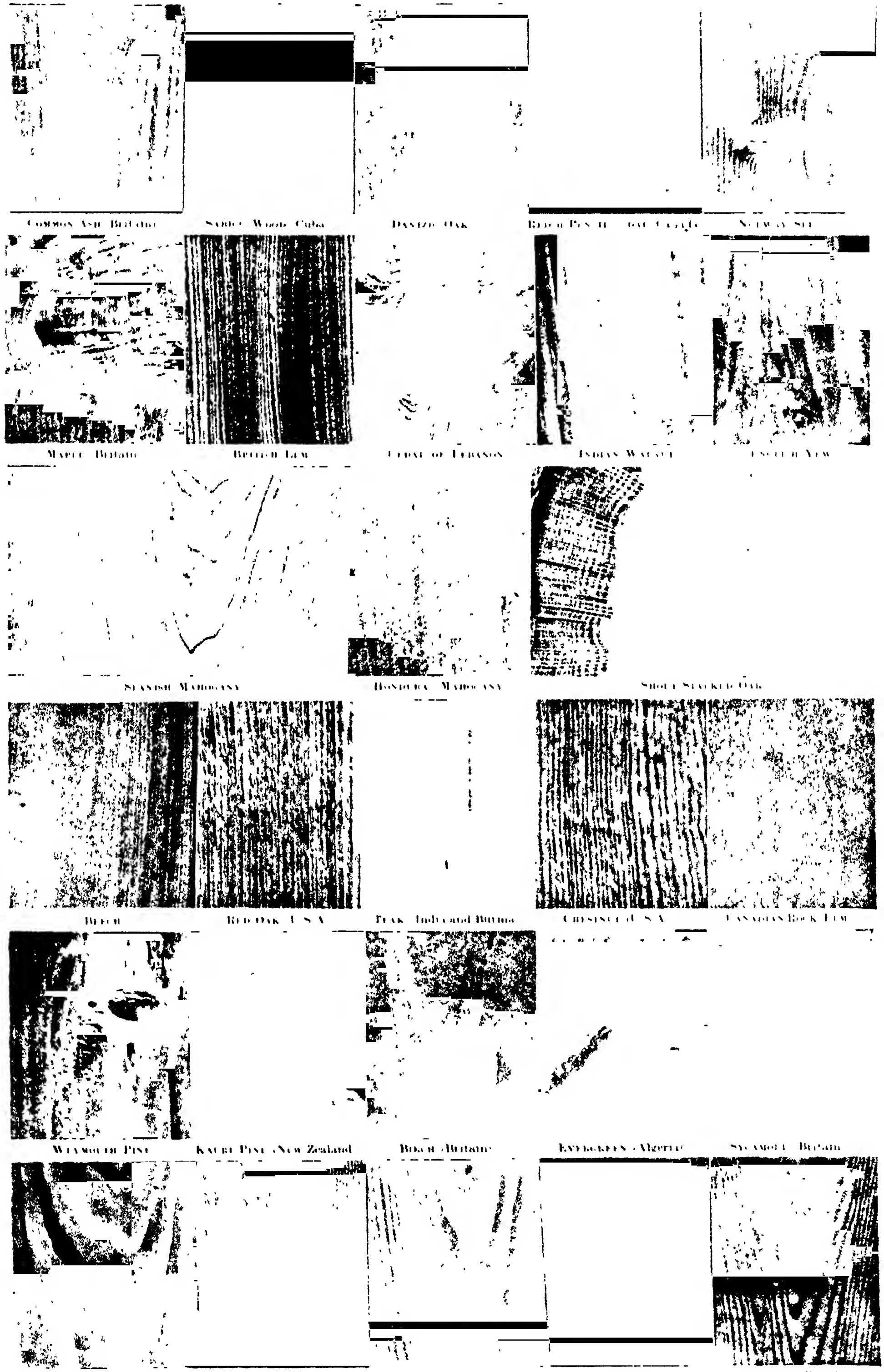
Coniferous trees generally produce softer wood than leaf-bearing trees, and in soft woods the sap-wood is usually of a greenish tinge, while in hard woods the darker they are the lighter is the sap-wood, so that the contrast is very striking. As soon as a tree is cut down it should have the branches lopped off, and then be drawn out into the open and raised off the ground, so that the air may circulate freely round it; if roughly squared it will season quicker, but it should not be cut into scantlings until it is fairly dry.

Seasoning. Timber which is given a proper time for seasoning is tougher and more elastic than that which has been rapidly dried. The newly-felled tree has the fibres more or less distended by sap, but as the moisture evaporates the wood shrinks, and it is very important to understand the mode in which shrinkage takes place. If a round log be cut into planks, as **5**, the process of seasoning will cause a shrinkage circumferentially, so that the planks will take new shapes as shown in **6**. If the medullary rays be compared with the ribs of a lady's fan then the shrinkage is similar to a partial closing of the fan, and an inspection of the grain at the end of a plank will show at once in which direction the distortion and shrinkage will take place. A piece of quartering [7] will show in a striking manner the effect of shrinkage, as in drying it will take the shape of **8**, losing the shaded portion and standing as **9**. The shrinkage in length is so slight that it may be disregarded, but the reduction of width in seasoning may cause a change in the shape of the ends as in **10**, where the dotted lines indicate the change. These effects may all be reduced by carefully drying the timber before converting it, but some varieties—*e.g.* pitch pine, not only go on shrinking in dry weather, but will expand again the reverse way when exposed to a damp atmosphere.

Defects. Timber is liable to numerous defects, principally shakes and knots. Shakes are cracks caused by the partial separation of the fibres longitudinally during seasoning; they are known, according to the shape and position, as heart shakes [11], star shakes [12], cup shakes [13], and wind cracks [14]. Knots are portions of wood where branches have been lopped off, as **15**, but unless they are dead and loose they do not present any serious drawbacks. Rind galls [16] are dead portions shut in by the annual rings, caused by some injury to the sap-wood of the growing tree, and subsequently covered by fresh layers. Sappy corners [17] and waney edges [18] are also defects. Some timber, such as mahogany, is liable to an upset in the grain, as **19**, sometimes called a thunder shake.

Doatiness and foxiness are dirty spots and stains in the cut timber, which may be taken as symptoms of incipient decay. Dry rot is a disease which causes the destruction of the interior fibres and converts the timber to a brown powder, but often leaves a shell of apparently sound material on the outside. Sap-wood and wood that has been insufficiently seasoned is most liable to it, and particularly if situated in a moist, close, stagnant atmosphere, as under a kitchen floor. It is generally associated with a fungus (*Merulius lachrymans*), which spreads over the surface and is very difficult to eradicate. If the evil has not gone too far it may sometimes be stopped by scraping the parts affected and painting them over with blue vitriol or sulphate of copper ($CuSO_4$), and inserting air-bricks in the walls. In bad cases the whole of the affected wood must be cut out and the walls scraped clean, as the fungus, if left for any time, is liable to spread over brickwork and masonry, and produce spores that may attack fresh wood.

Precautions Against Disease. There are various modes of rendering timber less liable to the attacks of disease, or of parasites, to which we may give attention. For outdoor use creosoting is, perhaps, the most important. This was formerly known as Bethell's process, and consists in impregnating the timber with creosote or oil of tar. It is usually performed in a closed wrought-iron cylindrical vessel, like the shell of a Lancashire boiler, say 7 feet diameter and 60 feet long, with a door at one end and tram rails laid along the bottom inside. The balks or planks of timber are placed upon trollies with chains or iron hoops over the top to keep the timber from floating when the creosote is let in, and the trollies are run into the cylinder. The door is then shut, and a vacuum of 7lb. or 8lb. per square inch is created to extract the air from the fibres. After a short interval creosote is allowed to enter, the vacuum is maintained until all the timber is submerged, and the pressure is then raised to about 150lb. per square inch. An average of 8lb. of creosote per cubic foot of



Common Ash (Britain) — Satin Wood (Cuba) — Dantzic Oak — Red Pencil Cedar — Norway Spruce

Maple (Britain) — British Elm — Cedar of Lebanon — Indian Walnut — English Yew

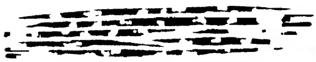
Spanish Mahogany — Honduras Mahogany — Short Stacked Oak

Beech — Red Oak (U.S.A.) — Teak (India and Burma) — Chestnut (U.S.A.) — Canadian Rock Elm

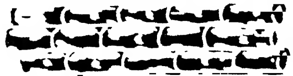
Weymouth Pine — Kauri Pine (New Zealand) — Birch (Britain) — Evergreen (Algeria) — Sycamore (Britain)

Larch (Europe) — Italian Larch — Dantzic Fir — Pitch Pine — Canadian Red Pine

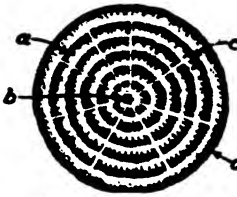
THE TIMBERS OF COMMERCE



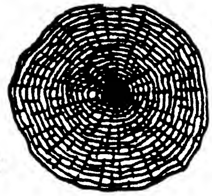
1. Woody fibre, magnified.



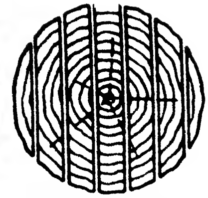
2. Cellular tissue.



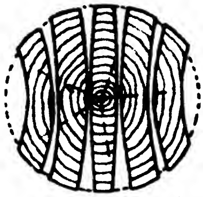
3. Section of young tree.



4. Section of oak.

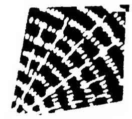


5. Section cut into planks.

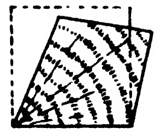


. Planks after seasoning.

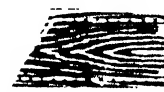
7. Quartering.



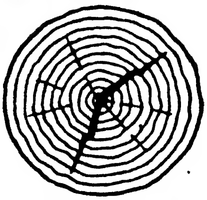
8. Shrinking.



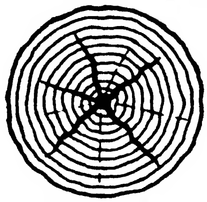
9. Form after shrinking.



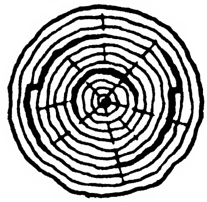
10. End after shrinking.



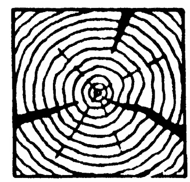
11. Heart shakes.



12. Star shakes.

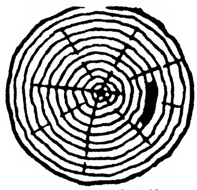


13. Cup shakes.



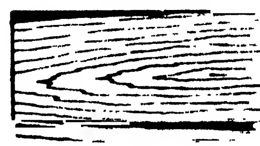
14. Wind cracks.

15. Knots.

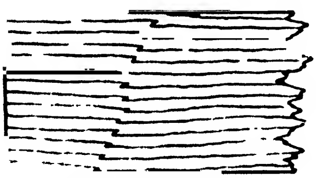


16. Rind gall.

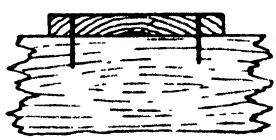
17. Sappy corners.



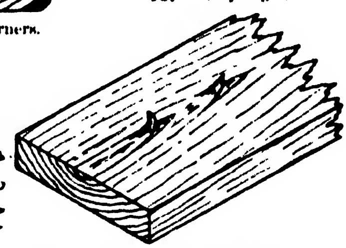
18. Waney edges.



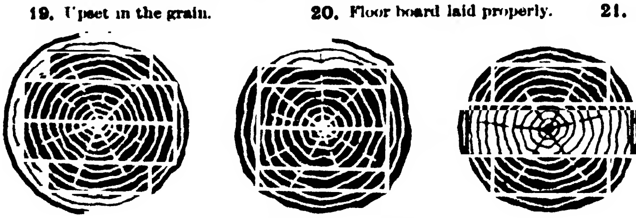
19. Upset in the grain.



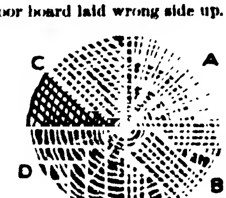
20. Floor board laid properly.



21. Floor board laid wrong side up.



22, 23, 24. Cutting pine and fir.



25. Methods of cutting oak.

26. The flower of the oak.

27. Cutting pitch pine for panels.

timber can in this way be forced in, and it remains there after the timber is removed.

This process is used mostly for paving blocks, for railway sleepers, for timber piles, and for jetty work, the strong smell rendering it unsuitable for indoor purposes. The Fire Resisting Corporation, Ltd., by a somewhat similar method, impregnate timber with an antiseptic and fire-proofing solution, which is forced into the fibres by hydraulic pressure. The trolleys are then run into a drying kiln, where the timber remains for about a month before it is ready for use. By the Powell process timber of all kinds, including cabinet woods, is placed in a saccharine solution, which has the effect of producing a chemical alteration in the sap, so that even green sappy wood can be rendered perfectly sound, and after drying is free from any tendency to shrink, warp, or decay. Many other processes have been tried with more or less success, but they have now fallen into disuse. The more open the texture of the wood the better it can be impregnated, and hence the various processes have been almost exclusively applied to Memel and Dantzic fir.

The Timbers Most Used. We will now turn to the different kinds of timber in ordinary use, beginning with the coniferous class, having spines instead of leaves, and bearing their seeds in the so-called "cones" of various sizes.

The most useful member of this class is the *Pinus sylvestris*, which is popularly known as Northern pine, Scotch fir, Baltic fir or pine, and red or yellow deal. The uninitiated have great difficulty in understanding the use of the terms fir, deal, and pine; *fir* should be used only for the products of the *Abies*, but it is used by carpenters for any soft timber used in scantlings—*i.e.* above 2 inches square, and it is used by quantity surveyors for any unwrought wood where the same piece would be described as deal if wrought—*e.g.* fir rough fillet or deal wrought fillet. The term *deal* again is used both for pine and fir, with the distinctive prefix of yellow and white respectively. Deal also signifies the size of a board—viz., 9 inches wide, planks being 11 inches wide, battens 7 inches, and narrow battens 4½ inches. The term *pine* is likewise used for various kinds of clean straight stuff, including yellow deal, red deal, patternmakers' pine, and pitch pine. The wood of the *Pinus sylvestris* is of a honey yellow with the annual rings rather darker, and giving figure to the wood when wrought. Some varieties turn a pinky-red when wrought, and this probably gives the name to red deals. It is, as a rule, straight-grained and very free from knots, and is known by the name of the port from which it is shipped.

Deal. The yellow deals from Christiania are considered the best, but they sometimes contain a large proportion of sap-wood. Those from Stockholm and Gefle are next in quality, but are more disposed to warp than Christiania deals. They are suitable for floors and other work where warping can be prevented. Stockholm and Gefle yellow are generally used for ground floors; Dram and Christiania white for upper floors. All floor boards should be laid heart side downwards, the curling being prevented by nailing the edges, as **20**; if laid otherwise, pieces in the centre, where an annual ring crops out, are apt to shell up [**21**] when the floors are washed. Swedish deals cannot be depended upon for joiners' work, owing to their extreme liability to warp. Gottenburg deals, though strong and durable, are not suitable for joiners' work. Archangel and Onega produce good deals for joiners' work, but they are not so durable in damp situations as Christiania deals; they make good warehouse floors and staircases. The best Russian deals in the market are those from Viborg, but they are inclined to sap; those from Narva and Petersburg are generally inferior. The knots in Russian deals are apt to be surrounded by dead bark. Memel is a very uniform and durable timber, imported in the log and very suitable for carpenters' work. The size, averaging 13½ inches square, makes it very convenient for use in civil engineering constructions, such as jetties. Dantzic timber, also in the log, runs to larger sizes up to 16 inches square; it has a coarse growth, and is generally full of large knots, often dead, and is subject to cup shakes. Riga logs are now seldom seen; they are the most uniform in quality, but do not run over 12 inches square. Swedish timber is generally deficient in resinous matter, and cuts with a woolly surface, but some of it may have thick annual rings and a quantity of resinous matter, which chokes the saw. Good timber, when freshly cut, should look clear and bright to the eye, and be firm and dry to the touch.

Pine. *Pinus rubra*, Quebec pine, Canadian red pine, or American red pine is very like Memel, but when knots occur in it, they are larger than in Memel. It is a clear, straight timber—soft, pliant, and easily worked—but not so strong or durable as Baltic pine. It is much used for joinery and mouldings.

Pinus strobus, American white pine, American yellow pine, Weymouth pine or soft pine, is much used for all purposes in its native country, but in England it is very liable to decay. There is scarcely any difference, either in colour or texture, between the inside and outside of the annual rings; it is clean, straight-grained, free from knots, and grows to a very large size. When freshly cut, the wood is perfectly white, but soon assumes a brownish tinge. It can always be recognised by short hair-like marks or black dashes in the grain. It is chiefly used by pattern-makers, and hence is known by the name of pattern-makers' pine; it is also used for door panels, on account of its width, but it is too soft for joiners' work in general.

There are several other varieties of pine occurring in smaller quantity. They are used as timber, but we need not specify them. One large class, however, known in England as pitch pine, needs consideration. The principal variety is, perhaps, that named *Pinus Australis* or Southern pine, or Georgia pine, found over a large tract of country in the United States. It is very resinous,

straight-grained and hard, free from knots, with the annual rings very regular and strongly marked. It is used for deck planking, treads of stairs, and similar purposes where its hardness and toughness are advantageous. It is also used for furniture, on account of its freedom from knots and strongly-marked grain. About one log in a hundred is found to have a beautiful curly grain, due to irregularities in the annual rings, and these logs are reserved for panels, which are, however, difficult to work, as the grain is apt to tear up. It is not good for beams, although very strong when new, as in course of time the resinous matter evaporates or dries up and the wood gets brittle. It is also not good "between wind and water"—*i.e.* for jetty and dock work—and not good for window-sills, although often used. It must be well seasoned before use, as it is particularly liable to shrinkage.

Fir. *Abies excelsa* or *Picea excelsa*. Spruce fir, or white deal, is largely imported into this country from Norway and Sweden, and from other Baltic ports. The best qualities are used for joiners' work and the common qualities for rough inside work. Christiania white deals and battens are best for panelling, for dresser tops, shelves, and the upper floors of houses; those from Friedrichstadt have small black knots; those from the lowland districts of Norway warp and split in drying.

The most durable timber is grown on the higher ground and the more northern latitudes, the growth is slower, and the wood is consequently more compact. Both good and bad deals come from Dram, known as Drammen deals. Gottenburg white deals are very stringy, with a woolly surface, and are used mostly for packing-cases. Narva supplies the next best to Norway, and Riga follows. Petersburg white deals are said to shrink and swell with changes of weather, even after being painted.

Young trees of spruce fir with the bark left on are used for scaffold poles; they may be obtained from 6 to 8 inches diameter and 30 to 60 feet long. The same poles cut down the middle are used for making ladders, straight grain being thereby assured. The wood of the spruce fir is light, elastic, tough, not difficult to work, and some varieties are very clean and free from knots, though when knots occur they are generally very hard and notch the plane-irons. The colour varies from pale yellowish to brownish white, the commoner qualities being almost perfectly white, and all turn bluish when exposed to the weather. There is very little resin in the grain, but it sometimes occurs in bold open streaks. Carpenters distinguish the qualities by calling the better ones white deal and the commoner ones spruce. Other varieties of this tree are the American white spruce, American black spruce, Canadian or hemlock spruce, Nova Scotian red spruce, and the silver fir. They are not much used in England.

Larch. *Larix Europæa*, or common larch, is an extremely durable timber in all situations. It is a very resinous wood, and the resin often exudes to such an extent as to form a varnish on the exterior, protecting it from the weather. It is particularly suitable for posts and sleepers, but, on account of its resinous nature, does not dry very readily, which renders it liable to shrink and warp if cut into boards. It is well adapted for floors and staircases, where there is much traffic. It bears driving bolts and nails better than any other resinous woods, and therefore makes good ship timber. The wood is of a honey yellow, the hard part of the annual ring being of a reddish cast similar to Memel, but more pronounced, and, on the whole, it has a browner appearance.

Cedar. *Cedrus Libani*, or Cedar of Lebanon, is one of the most durable timbers, of a yellowish brown, with distinct annual rings, powerful odour, and slightly bitter taste. It is straight-grained and easily worked, but liable to split. The cedar in common use is, however, the Virginian red cedar (*Juniperus Virginiana*). This is largely used for wardrobes, drawers and boxes, as the taste and smell keep away insects. It is the well-known wood used for covering blacklead pencils, and hence is often called pencil cedar.

Yew. The common yew (*Taxus baccata*) is a beautiful wood for cabinet-making, but takes a long time to dry. Where it is plentiful it is very good for fencing. The cypress (*Cupressus sempervirens*) is an ornamental evergreen tree often found in English churchyards. It is here slow growing and does not attain a large size, but in the South of Europe it grows larger, and is supposed to be the most durable of all varieties of timber.

New Zealand Pine. The New Zealand pine (*Dammara Australis*) is a coniferous tree that deserves to be better known. It is said to grow to a height of 80 to 140 feet, with a straight, clean stem 4 to 8 feet diameter. Although it contains a considerable amount of resin, this exudes while the tree is growing, so that it is not particularly noticeable when the log is converted. The wood is close, even and fine-grained, the texture uniform and slightly mottled, the colour a light yellowish brown or full honey yellow, with a silky lustre, and the annual rings are only slightly marked. It cuts very uniformly in any direction, is easily worked, and yet tolerably hard. It unites well with glue, but is apt to split in nailing. It is used in England principally by pattern-makers for patterns for small brass work, but makes beautiful panels for yacht cabins, and might be used largely by cabinet-makers and joiners.

Hurst's edition of Tredgold's "Carpentry" may be consulted for much useful information relating to timber and its uses. The marks upon timber have not been referred to, as they are so numerous and frequently change, but they have to be known in making purchases, as they nearly all indicate some specific quality.

Oak. Among the non-coniferous trees, or hard woods, oak (*Quercus*) is the most important. There are three principal varieties grown in England—the Old English oak or stalk-fruited (*Quercus robur* or *Quercus pedunculata*), which may be known when growing by the acorns having long stalks and the leaves short stalks;

the Bay oak, or cluster-fruited (*Quercus sessiliflora*), whose acorns grow in close clusters with very short stalks, the leaves having longer stalks; and the Durmast oak (*Quercus pubescens*), whose acorns and leaf stalks are similar to the Bay Oak, but the leaves are somewhat downy on the underside.

The timber from the stalk-fruited oak is considered to be superior to the others; it is lighter in colour, has a straight grain generally free from knots, and has numerous and distinct medullary rays, and consequently good "silver-grain" or "flower." It is easier to work and less liable to warp than the bay oak, it splits well and makes good laths, and it is suitable for all kinds of work. The wood of the bay oak is darker, tougher, heavier and harder, but has few large medullary rays, and is liable to warp. Durmast oak is inferior to either. Quebec oak or American oak (*Quercus alba*), called white oak from the colour of its bark, has a pale reddish brown colour with a straighter and coarser grain than English oak, is sound, hard, and tough, and bends easily when steamed. Dantzic oak is of a dark brown colour, with a close, straight and compact grain, bright medullary rays, free from knots, very elastic, easily bent when steamed, moderately durable.

Riga oak is similar, but has more numerous and more distinct medullary rays; it is imported in half round logs. Italian oak is brown, hard, tough, strong, subject to shakes and difficult to work, but free from other defects. Wainscot oak is timber so converted as to show the silver grain, or flower, to the best advantage. Clap boarding, imported from Norway, is a sort of inferior wainscot, distinguished from it by being full of white-coloured streaks. Oak is a good all-round timber in point of strength, durability, and general application; it stands exposure to the weather better than most others.

Chestnut. The chestnut used for building purposes is the Spanish chestnut (*Castanea edibilis*), not the common horse chestnut, which is a spongy, whitish wood of little or no use. The Spanish chestnut is only grown to a small extent in this country at the present time; it may be known by the leaves being smoother, darker, longer, and separated more distinctly. The wood is much like oak in colour and general appearance, but has rather more of a cinnamon cast of colour, less sap wood, and generally a closer grain, although softer and not so heavy as oak. The chief distinguishing characteristic of the chestnut is the absence of the distinct medullary rays, which produce the flower in oak, and old roof timbers, benches, and church fittings may be discriminated in this way, also by the chestnut being more liable to split in nailing, while the nails never blacken the timber from the formation of ferro-gallic acid as they do in oak. Reports vary, but the general opinion is that the roof of Westminster Hall is oak, and the circular part of the Temple Church of chestnut.

Beech. Beech (*Fagus sylvatica*) is a close-grained hard wood, with remarkably distinct medullary rays in small plates, showing when cut across as small strokes. The wood is a whitish-brown, very suitable for machinery, for the stocks and handles of tools, and for many other purposes. It soon decays when exposed to alternate drought and moisture, and is very liable to the attacks of worms. For cabinet-making it is stained to represent rosewood and ebony; it is also used by glass-blowers on account of its freedom from deleterious matters; engineers use it for piles under water and for wedges.

Elm. Elm (*Ulmus campestris*) is a very open-grained wood of a reddish-brown, and is generally much twisted in the grain. It is fibrous, dense, and tough, and bears driving nails very well. It is not used in small scantlings on account of its liability to warp; it is useful for piles and for planking in wet foundations, but decays rapidly if exposed to alternations of moisture; it is much used for pulley-blocks, naves of wheels and coffins. The American elm (*Ulmus racemosa*) is much lighter in colour than the common elm and of a different character, being clean and straight in the grain, tough and flexible, free from knots and sap, and can be wrought with a fine smooth surface. It is much used for ships' rails and for the fender pieces of jetties.

Ash. Ash (*Fraxinus excelsior*) is a light brownish white with longitudinal yellow streaks, each annual layer is separated from the next by a ring full of pores. It is remarkably tough, elastic, flexible and easily worked, with very little sap wood, but requires to be sawn into planks soon after felling, as otherwise deep shakes open from the surface. The planks should be stacked with small fillets between, so that they may season without warping. It is very useful for long tool handles, shafts, spokes and fellows of wheels, wooden springs, and wherever it has to sustain sudden shocks. It is very durable if kept dry, but soon rots when allowed to become alternately wet and dry, and is subject to the attacks of worms. It is used for wardrobes and other cabinet work on account of the colour and figure of its grain.

Birch. Birch (*Betula pendula*, *B. alba*, etc.) has a straight grain and sometimes well figured. It is hard and tough, stands wear and tear; is an excellent wood for the turner, being light-coloured, compact, and easily worked; is much used in cabinet making and for furniture of various kinds; when stained and varnished it is not easily distinguished from mahogany. American birch is used for putlogs. Russian birch, called also Russian maple, is well figured and of a full yellow colour.

Mahogany. Mahogany (*Mahogani swietenia*) is obtained from Central America and the West Indies. The former is known as Honduras mahogany, and the latter as Spanish mahogany. Honduras mahogany is similar to cedar in colour, of somewhat straight and coarse grain, makes soft silky shavings, and is worked with very little waste, if care has been taken in seasoning. It makes very good panels in

importance of educational travel upon its readers, and indicating how best to pursue this important branch of self-education.

Travel and Book-knowledge. We dare venture to say that if we were to describe travel as the most valuable part of any man's education we should not be greatly over-estimating its importance. It is difficult to think of any occupation, requiring skill and observation, in which the worker would not be the better fitted to engage if he had some intelligent travel in a foreign country. True, much may be learned from books, and reading about other lands and peoples must go together with visiting them. We have met persons who, never having visited a foreign country, were still, thanks to their book-knowledge, better informed concerning its manners and customs, its people and their history, than others who had often been to that country, but who had travelled without profit; tourists, in a word. One of the finest descriptions of Italy ever penned is to be found in "John Inglesant," and at the time he wrote it the late J. H. Shorthouse had not been across the Channel. Many such instances might be given; yet all combined would form no argument against our case for the educational value of travel, just as the gaping tourists who never acquire any real knowledge of the places they visit and the people they see must not be quoted against us, since we submit that they are not in any true sense of the word travellers. They are to the man who travels for education, or intelligently, as the gobbler of cheap library fiction is to the serious student of books.

The "Wander-Year." One of the reasons for the enormous advance industrial Germany has made in our time is to be found in that old Teutonic custom, the Wanderjahr, or Wander-year. As soon as an apprentice is out of his time, he fares forth on a year's wandering through the country, plying his craft in different towns and villages, and gaining thus a breadth of mind and experience which is invaluable to him in after-life. Such a youth is worth far more in resource and knowledge than a workman who has never been beyond a day's journey from home, be the latter never so diligent. He is, indeed, the veritable "journeyman," and can we wonder that a nation of such journeymen advances? The Wanderjahr also serves to implant in the German that intense love of travel which is so characteristic of the people. One cannot wander about the Continent any summer without encountering little groups of young Teutons with their knapsacks and stout staffs; pilgrims of knowledge.

So vitally important to the growing prosperity of any country is an enlightened and alert people, that it is surprising our educational leaders have not in the past insisted more strenuously on the absolute need of foreign travel as a part of general education, instead of leaving it to flourish chiefly as a pleasure or a pastime. True, it were a most desirable thing that certain features of education did become popular as pleasures: the study of languages, for instance; but, broadly speaking, that which is carried through *entirely* in the spirit of pleasure, and chiefly with the desire to amuse or to pass the time, is not calculated to leave on the mind any real educational effect.

Serious Holidays. We do not wish to be held as urging that pedagogic travel should take the place of all other recreations; no view so extreme has been present for a moment in our mind. But what we do contend for and should delight to help in bringing about is, that young people, and indeed all who can still travel either at home or abroad, would regard their annual vacations with less of levity and with a thought more of seriousness than they are, for the most part, at present apt to do. For this touch of serious purpose to what may still be pleasure of the most desirable and enduring kind would have a wonderful effect in raising the national standard of enlightenment; incalculable. Holidays should not be merely the annual recreation of Jones, Brown, and Robinson; but the annual recreation of a whole people, a process that should help to fit them the better for their part in the world's work and destiny. It is this wide national view of a matter, that is only individual because the State is made up of individuals, which we are anxious to urge before we come to the closer consideration of its bearing on the character and career of the average citizen.

A National, not only a Personal, Matter. Assuredly it is no mere personal matter, this of educational travel. It is eminently national in its importance. And to Britishers more than to any other nation, as our insular situation renders us peculiarly liable to cherish erroneous opinions of the world's economy. Inversely, our insular circumscription has made us the world's colonisers. Our bolder spirits in times past, and not less to-day, have from the very fact of our territorial limitations sighed for wider realms and adventured into far lands with the wondrous results of which we are all so proud,—many of us with so little personal reason. The Scots are pre-eminently the colonisers of the British Empire —in Canada, Australia, the Cape, everywhere, the Scot is prominent, because his own land is so small and so lacking in riches that he must travel to distant parts if he would improve his condition. To the Frenchman, the German, the American, it is almost enough that he travel his own great land; yet not enough, wide and abundant in interest as these countries are, for there are thousands of clerks in the United States who do not know the postage rates to England, all their interests being so exclusively American; it is possible to be insular in one's knowledge and yet to live on a great continent. Still, the countries named, and especially the United States, have far more to offer their citizens who confine their travels to them than England has for Englishmen. A Frenchman who knows France from Maubeuge to Marseilles, from Nancy to Nantes, knows more of the world and humanity than an Englishman who knows his native land from the Tweed to the Solent—and he is not more rare. Knowledge of our own country is not to be despised; in fact, it must come before foreign travel, and

we will assume in all that follows that the reader is reasonably familiar with his own land; but one short journey to the Continent, if his eyes be open and his mind likewise, will teach him more than a lifetime in England. Yes, more of England!

"What should they know of England who only England know?"

Why We Must go Abroad. It has been well said that the whole art of painting a picture is knowing just where to sit down. That is, how to get the point of view. Similarly, the art of knowing how to appreciate and to understand one's own country lies in choosing the point of view, and it needs no insistence to advance the proposition that in order to come by this point of view one must go outside the country. We may be participants in a procession and know nothing whatever about that procession. "The looker-on sees most of the game." *To see* England, go to France, Germany, anywhere but England. That is the best way, the only way, to intelligent patriotism. As nothing is appraisable save relatively, or by comparison, we must know something of the life of other peoples, the characteristics, natural and social, of other lands, before we can presume to estimate these qualities as they are exhibited in our own land. All this is so obvious, that it seems to be unnecessary to set it down; but that is precisely why the need exists, as it is the obvious which people are most apt to ignore or to omit to profit by. Certainly these very obvious considerations are by no means present in the minds of the majority of British people, or, at least, there is no evidence in their actions that they are influenced by them.

How Travel Modifies our Ideas. In Manchester, Liverpool, Birmingham, Glasgow, Leeds, and other great provincial centres, we should have no difficulty in finding thousands of young men and women who have never visited London. Think how some first-hand knowledge of London ways must correct and modify the local impressions of these young people. Then consider how similar knowledge of Paris, Brussels, Berlin, Madrid, and Rome—or any single one of these capitals—would, by many times multiplied, modify their impressions of things. Why, in the day that a young man steps ashore at Calais he has done far more than he ever did when he passed into a higher class at college. He has opened the door of his mind to the entrance of the newest knowledge in the world: *his own* impressions of a foreign land. Of itself this may seem a small thing, but in its effect upon an intelligent and ardent mind it is an immense thing. That mind will never again think of England and of life from the insular point of view; cannot. It is not at all necessary to go far afield to intensify the impression: Egypt will serve hardly better than Belgium, not so well as Rome or Etruria, in vivifying the spirit of antiquity. A stay of a week in Bruges, in Ghent, in Ypres, combined with the book-study of these old towns, once so magnificent and so populous, now shrunken in decay (for even busy Ghent is but a shadow of its former self) would have a wonderfully *quietening* effect upon the mind of a youth who has been reared in the narrow local patriotism of Glasgow or Birmingham; while Brussels, with its splendid boulevards and handsome public buildings, its bright and happy life, would enable him more accurately to gauge the conditions of his own town. This need not, will not, make the young mind less patriotic, but more intelligently so, alert to shortcomings and keen to remedy them. In point of fact, we have only to notice how frequently the corporations of our large towns are sending deputations abroad to study the ways of Continental cities if we wish a ready illustration of the value of foreign travel. Seldom does any British corporation undertake an important public work, a new tram service or water supply, without preliminary study of other towns in their treatment of the same matter. To the intelligent observer there is no foreign town which will not show him many things worth doing or equally worth avoiding.

How it Aids Citizenship and Patriotism. This all makes for better citizenship. The more a man knows of other towns the shrewder is he in criticising his own, the more alive to its faults and equally to its advantages. And these are the citizens that we want to-day: not people proud and arrogant from ignorance, but appreciative and loyal from knowledge, and, seeing what is good in other places, keen to adapt it to their own. In the same way this aspect of foreign travel includes the larger patriotism: the temperate and reasonable loyalty of men and women who love their own land and know it best because they can view it in relation with others. That is the patriotism, above all, we need most now and in the future. For it is clear that Britain has entered upon a new era of international politics, *demanding of her people no purblind devotion to the British flag, but a sympathetic understanding of the other great peoples of Europe,* who are neither fools nor rogues, but nations as highly civilised as ourselves, as honest, as lovable, as human, and perhaps more interesting to us, as we are so to them. It is a wholesome thing to the confident Cockney to discover one day that he too is a "foreigner" when he lands at Boulogne; then begins a process of modifying his Cockney confidence and pride, which, if continued, can have nothing but the most desirable results. If we saw—and we think we can at least see signs of this—the Germans, the French, and the British increasingly keen on travelling in each other's country, not to sneer at, but to observe and to understand each other, *there* would be the best possible guarantee of international peace. For this we must bear in mind: he is a poor traveller who returns to scoff at his own land, and does not always feel ready to adopt those words of Goldsmith, applying them to his native land:

"Where'er I roam, whatever realms I see,
My heart, untravell'd, fondly turns to thee."

The more personal side of foreign travel has been barely touched upon thus far, and will form the subject of our next chapter.

To be continued

TEXTILES. DYES. DYEING

A COMPLETE PRACTICAL TREATMENT OF THE TEXTILE TRADES

COVERING

ALL PROCESSES FROM THE RAW MATERIAL TO THE FINISHED ARTICLE

AND DEALING WITH

All Kinds of Materials	Draughting the Web	Lace and Hosiery
Preparation of Fibres	The Loom at Work	Canvas and Linoleum
Felted Fabrics	Finishing Processes	Carpets and Mats
Yarn M[illegible]	Artificial and Mixed Fibres	Twine and Rope

WITH A TREATMENT OF

DYES AND DYEING, DYE MIXTURES, DYEING MACHINERY, AND ALL THEIR APPLICATIONS

BY

W. S. MURPHY, Journalist and Technical Expert in all the Textile Industries
HERBERT ROBSON, Bachelor of Science and Gold Medallist of London University

WOOL: AN INDUSTRY OLDER THAN ALL CIVILISATIONS

By W. S. Murphy.

APPARENTLY an artificial product of civilisation, the textile industry has its roots deep in the constitution of the world. The prehistoric beginner of textile manufacture, though most probably unaware of it, was merely imitating one of nature's most common processes.

All animal and vegetable tissues are formed by the combination of slender threads, or fibres, or filaments. When we refer to the fibre and texture of wood, or flower, or flesh, we use no figure of speech, but speak simply of those things as they really are. Thread by thread, nature builds up the tissues of all organisms; she is the original spinner and weaver, and man is her feeble imitator. By microscopic analysis it has been found that the fibres visible to the naked eye are themselves composed of fibres, and that these fibres are made up of smaller fibres still, down to filaments so slender that the human eye fails to detect them.

The Basis of Textile Industry. This principle is observed throughout the process of textile manufacture. If a piece of woollen cloth is separated into its parts, two sets of threads come apart; examination of one of these shows that it is composed of threads still more slender, and these again are found to be composed of thin fibres twisted together. At this point the threads cease to be continuous, and fall apart into a series of fibres which have been combined. Nature's threads and tissues do not fall apart in that way, because her weaving is a vital, organic process, while man's fabrication is purely mechanical.

In comparing the organic texture of natural tissues with the mechanical combinations of textile industry, we do not mean to depreciate human art. Textile industry is based on the fact that certain fibres will mechanically combine so intimately as to form a perfectly homogeneous whole. This is the root quality of the textile manufacturer's raw material, which places in a single category fibres so diverse as cotton and mohair, hemp and silk. With unerring precision the test eliminates the textile from the non-textile fibres. Put, for example, a pair of human hairs beside a pair of wool fibres. Though carefully twined, the hairs come easily apart. Laid carelessly together, the wool fibres cling. A tuft of thistle-down, closely resembling cotton in superficial aspects, can be blown apart by a breath; the fibres of a tuft of cotton wool yield up each other only under delicate yet forcible pressure.

An Aggregation of Industries. The object of textile industry is to form vegetable and animal fibres into threads and fabrics for use and adornment. No one needs to be informed that there are many fibres used in the industry, numerous kinds of thread produced, and fabrics still more numerous. While one great aggregation—ultimately, we believe, to be resolved into unity—the textile industry is divided definitely into great branches, each containing many different trades. If every branch of the industry used a different material proper and peculiar to itself, and observed special methods and processes, classification would be a simple matter; but the two staple processes, spinning and weaving, are common to all, and one manufacture complicates with another in diverse ways, the cotton weaver taking weft from the silk spinner and the carpet weaver getting jute warp from the jute mill, the wool spinner using the cotton spinning mule, and the cotton spinner in turn applying the wool comber to his purposes. This complexity brings out an important truth. No matter what branch of the textile trades a man chooses to follow, he

ought to make himself acquainted with the general principles, at least, of the whole industry.

The Principal Fibres. Textile fibres may be likened to the lines at a great railway terminus; they start parallel and give off one branch after another, finally diverging at the door of the market. The principal fibres are—Wool, Cotton, Silk, Flax, Hemp, Jute, Coir, and China Grass—otherwise known as Ramie.

With the modern growth of the textile industry, and the consequent enormous demand for raw material, attempts have been made to introduce other fibres as substitutes for these; but the selective judgment of mankind seems to have well-nigh exhausted the field. Taking the fibres as termini, we find Wool branching off into Felt, Yarn, Woollen, Worsted, Carpet, and Hosiery Manufactures; Cotton into Calico, Muslin, Fancy Cloth, Sewing Thread, and Lace; Silk into Silk Yarns, Sewing Thread, Ribbons, and Cloths; while Flax, Hemp, and Jute resemble a series of local branch lines, more or less associated, producing, in a variety of combinations, Linens, Damasks, Canvas, and Floorcloths, Sailcloth, Mats, Ropes, and Twine. Before he starts, say, on the Cotton line, that is to bear him far into the heart of the muslin factory, the student should take a careful look at the various fibres employed in the textile industry and note the particular qualities of each. Let us set them down.

WOOL. Hollow tube, clothed with triangular scales set in pairs, giving a wavy character to the structure; soft, bright, firm, and elastic.

COTTON. Flattened tube, sides flanging inward, the whole fibre tending to twist.

SILK. Double tube, covered with clinging gum; soft, bright, and flexible.

FLAX. Built up of transverse layers, showing serration; fine, flexible, but woody in texture.

HEMP. Coarser than flax, but similar in structure.

JUTE. Soft, thick fibre, lustrous; grows to great length.

COIR. Wavy, serrated, coarse, but shows great density of structure; derived from the cocoa nut palm.

RAMIE. Long and slender fibre, with adhesive property; allied to jute; lustrous and transparent.

WOOL AND ITS MANUFACTURE

The Woollen industry is older than all existing civilisations. Like many another art, the manufacture of wool has risen and fallen with the rise and fall of nations.

Who first used the sheep's woolly coat for a garment is unknown. The inscribed tablets recovered from the buried cities of Western Asia and Southern Egypt show that woollen manufacture was practised by nations whose origin and end are unknown. In the very earliest traditions of our race the sheep figures as the useful property of man. We read in Genesis: "And Abel was a keeper of sheep." Job, the hero of the oldest book in the Bible, possessed in the days of prosperity which gladdened his age and repaid his sufferings, 14,000 sheep, and was doubtless a large exporter of wool. Solomon sings of the virtuous woman: "She layeth her hands to the spindle, and her hands hold the distaff." Ancient poetry abounds in reference to the industry. Homer, in the "Odyssey," describes Penelope weaving the shroud of Laertes, while her maidens spin the wool, the faithful wife of the absent hero warding off her importunate suitors by lengthening out her task, unravelling at night what she had woven through the day.

An Ancient Craft. Centuries later, Ezekiel spoke of Tyre as the market of white wool from Damascus and blue cloths from the tribes of Syria. Nineveh and Babylon were great centres of woollen cloth manufacture, and Persia, shorn of her ancient glory, still sends carpets to the palaces and mansions of the West. Lady Lugard has gathered records of vanished African empires, where woollen garments, stiffened with gold, were worn by kings and chiefs. All round the world, "from China to Peru," wool has been used for clothing, for comfort, and for ornamental fabrics, from times beyond the beginnings of recorded history. The woollen industry is, as the old Guild charters say, "a most ancient and honourable craft."

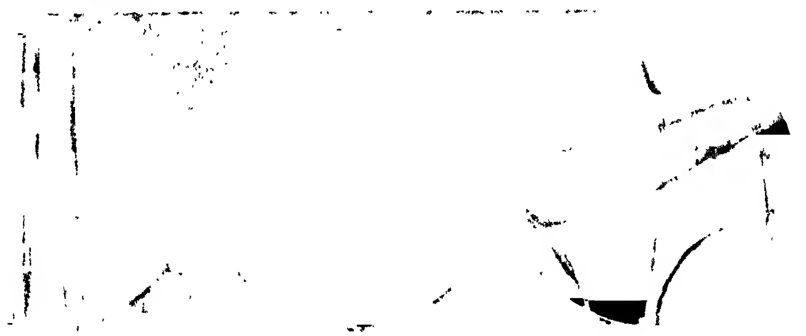
Yet the industry is still developing. The factories of Nineveh have vanished without leaving a trace, but new factories rise every year in Yorkshire and Lancashire; the dyers of Tyre are lost to fame, but their successors work in the laboratories of Vienna, Berlin, Paris, Bradford, Manchester, Massachusetts, and New Jersey. On the sites of Babylonian weaving factories the Arabs felt the tent-cloths with their feet. The old races attained civilised life, perfecting their industries; they sank into barbarism, degenerated, disappeared, taking their industries with them. New races, or races held in reserve, came forward, and found the arena of world-culture empty. Truly we are the heirs of all the ages.

When Caesar came to England. It seems to be proved that, when the ancient Celts came over to the British Isles, they knew the art of felting wool. According to Cæsar, the inland tribes, in 55 B.C., wore the skins of beasts, when they wore anything but paint. He does not mention, however, as appears from other evidence, that the inhabitants of the southern coast wore a short kilt of felted wool. Very probably the inlanders were equally acquainted with the art, but were too busy subduing the land to pay much attention to clothing. A similar difference might have been observed not a hundred years ago between the inhabitants of the American coast towns and the farmers of the inland states. The Romans found British wools much better suited for their clothing than the wools of Spain, because they felted more easily, and assiduously taught the Britons the art of cloth-making. Authentic proof of this was given by the discovery in Spitalfields of an

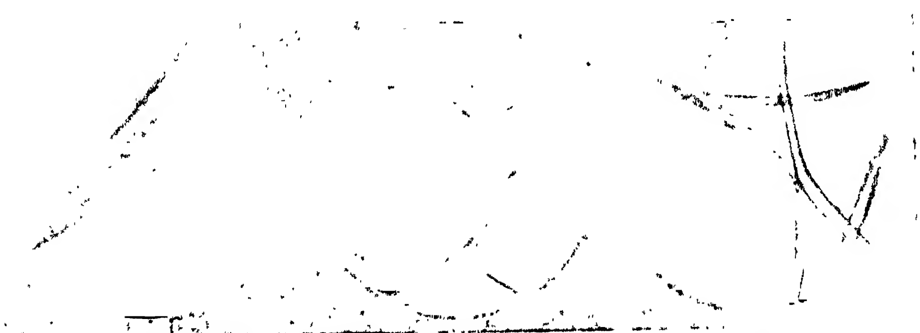
early Roman sepulchral monument erected to a soldier who is represented with a short kilt and plaid. Shattering though it may be to a proud Highland boast, we are compelled to believe that the Tartan kilt and plaid, so glorious in our military annals, originated somewhere on the banks of the Thames.

Work of a King's Daughter. After they had conquered England, the Saxons, wooed by the beauty and richness of the land, settled down to peaceable pursuits. Farmers and cattle breeders as they were, they recognised the value of the British sheep, and developed a wool trade with the weavers on the Continent. William of Normandy knew that the weavers of Rouen and the wool merchants of Caen were frequently hampered in their trade by the fluctuating restrictions imposed on wool exports by English kings. Were the two countries united, those restrictions could be abolished. That William had economic as well as political purposes in his mind when he invaded England is proved by the fact that he brought with him a company of Flemish weavers and settled them in Spitalfields soon after the momentous victory at Senlac.

An Industry of Native Growth. From this point the history of British woollen manu-



Jute Flax Silk



Hemp Cotton Wool

THE PRINCIPAL TEXTILE FIBRES AS SEEN UNDER THE MICROSCOPE

So large became the demand for English wool, that Ine, the good king of the West Saxons, about 694, thought it wise to order that "a sheep and its lamb be valued at a shilling." Another of Ine's laws prescribed "that the fleece alone be valued at two pennies—that is, at one-sixth the price of the entire sheep and lamb." King Alfred's mother is described as "spinning wool," and the great king himself did much to foster and consolidate the trade. Alfred's strong and war-like son, Edward the Elder, who began to reign in 901, "sette his sonnes to schole and his daughteris he sette to wool worke."

There can be little doubt that the high quality of English wool, and the wealth it brought, was one of the chief causes of the Norman conquest.

facture branches out into many diverse channels. It is the history of numerous different trades, each developing on its own lines. We see, however, that the industry is of native growth, no alien craft transplanted from foreign soil. Stimulated and strengthened by migrations of skilled workers from the Continent, it has been English in the main, with the English character stamped deeply into it. This is more important than at first may seem. Aptitude is inherited, and while a foreign craft may be mechanically performed, the trade which utilises familiar things grips a man, and impels him to give his whole mind to the work.

Taken by themselves, the fibres of wool, soft, silky, serrated, and curling, are natural products

of little value; he must have been a great poet who saw in them the potentialities of cloth. Labour, labour of brain and heart and hand, is the one and only "philosopher's stone" which transmutes the common things of earth into sources of human wealth and joy.

Process of Manufacture.

The task of the woollen manufacturer *is to convert wool fibres into some kind of fabric.* Alone he could not do it, for the task involves a long series of processes carried through in rapid succession by skilled workmen and complex machinery. The master of his craft knows every process, but as a practical workman he could only attend to one. The victim of this long series of operations is the wool. In the form of a fleece it is flung on the sorter's bench, and broken apart into twelve or fourteen different qualities, according to the breed or variety of sheep.

When a bag has been filled with the quality in demand, it is hurried off and flung into the steeping pans of hot water and soap, "soused," lifted out, squeezed, and thrown into the scouring vats. After being forked about among the scouring liquor and sent out of one bath into another, the last filled with clean warm water, the wool is finally dried.

Soon the scene changes, and now the wool is thrown into noisy machines; it passes through one that tears all its locks apart with fierce teeth, and into another that searches through every fibre for burrs and thorns; then it is borne onward into the grip of a machine with little spiky rollers which pinch and pu and draw, loosening the clinging hold of fibre or fibre, and, passing through a series of these machines, comes out a long soft rope. The wool has now changed its form, and at this point may be sen in one of two direc tions. It ma; either be put o the combing ma chine and prepare for being mad *into worsted,* o *it may be set on* the condenser for manufacture into woollen yarn. If destined for the condenser, the sliver, as the soft rope is called, is wound on short drums, which are hung at the end of a long machine, fitted with brush cylinders and rubber rollers. The brushes gently lead the soft slivers under the rubber rollers that roll and oscillate, forming thick threads which are wound on to large bobbins.

The Thread.

Now a *thread,* the wool goes to the spinning machines, which draw out and fine the thread.

When of the proper fineness, it is reeled into *hanks,* and is *yarn.* Meanwhile a designer has worked out a pattern, and in obedience to his plan, sections of the wool are taken, some to be bleached, some to be mordanted, reddened, blackened, purpled, or crimsoned, in the dye-house. Then all are brought back to the winders in the factory, who wind one part for weft on shuttle cops, the other on to bobbins for the warpers. The yarn is warped, dressed, wound on a weaving beam, and healded, then mounted on the loom, where it is woven into *cloth.* Though the wool has become cloth, its troubles are not over. It must go

ALL CLASSES OF WOOL.

(The figures after names indicate average length.)

1. Merino Lamb's, $2\frac{1}{4}$ in.
2. Lamb's, South American, $1\frac{1}{2}$ in.
3. Merino Greasy, super-clothing, $2\frac{1}{2}$ in.
4. Sussex Downs, 3 in.
5. Alpaca, $7\frac{1}{2}$ in.
6. Greasy Fine Botany, $3\frac{1}{4}$ in.
7. Cheviot, $4\frac{1}{2}$ in.
8. Skin or Dead Wool, 2 in.
9. Greasy Fine Crossbred (Australian), 3 in.

through the finishing processes, be *buried*, filled with soap, milled, teasled, shorn, steamed, and pressed.

Such, in outline, are the leading features of woollen cloth manufacture. There are other processes, similar in many respects, but different in others, for the making of worsted cloths, felts, carpets, and other fabrics. We shall meet with these in their proper places.

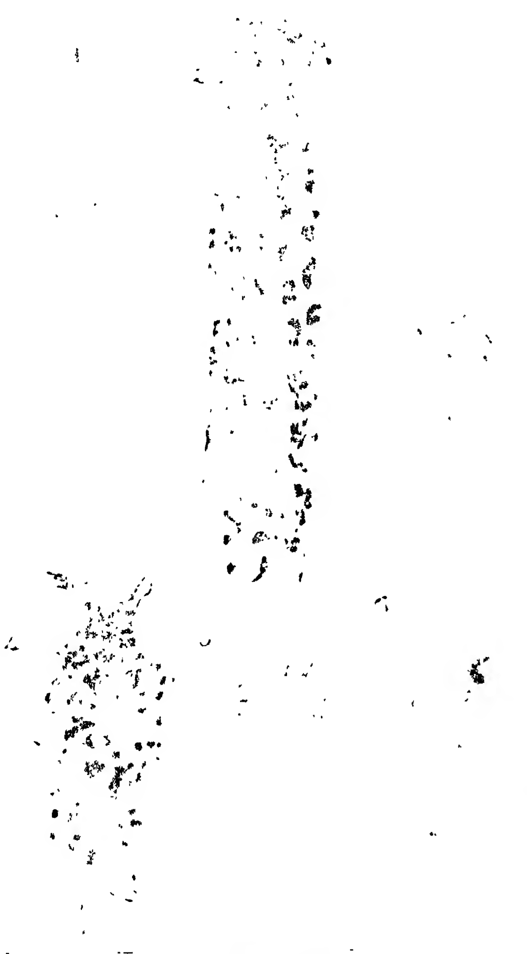
Materials. If the woollen manufacturer were allowed to operate on pure wool alone, his task would be a comparatively easy one; but modern conditions make far larger demands and require him to utilise with understanding, not only the numerous classes and varieties of wool, but also a large number of other kinds of raw materials. Nearly every textile fibre, in fact, comes into the woollen industry.

The reasons for this are various. Sometimes a cloth has to be enriched, and silk is employed: in another case, notably carpets, the warp must be a strong material, and linen forms the warp; to lighten and cheapen the fabric, cotton, noils, shoddy, mungo, and extract are mixed in.

The raw materials of the woollen manufacturer are classed under three heads:

1. ANIMAL FIBRES. Wool, hair, and silk.
2. VEGETABLE FIBRES. Cotton, flax, hemp, and jute.
3. ARTIFICIAL FIBRES. Noils, shoddy, mungo, and extract.

The two first classes are easily identified, and we shall be thoroughly familiarised with them in due course; but the artificial fibres belong to a class by themselves, and are peculiar to the woollen industry. Some description of them is, therefore, necessary here.



ALL CLASSES OF WOOL.

(The figures after names indicate average length.)

1. Lincoln Hog's, 10½ in.
2. Leicester Hog's, 12 in.
3. Yorkshire Hog's, 10 in.
4. Mohair, 8 in.
5. English Greasy Lustre, 6¼ in.
6. Irish Hog's, 8 in.

Noils. This fibre is the refuse of the combing process. Combing wools are, by implication, long, and the comb is employed to sort out those fibres not up to the standard. The noils, as the rejected fibres have been named, are otherwise good, and may be mixed in with the same class of wool for making woollen cloth, or, if broken, may be handed over to the felt-making or shoddy departments.

Shoddy. Manufacturers pleasantly name shoddy "manufactured wool." The term is speciously descriptive, for the material is made from wools which have passed through the process of manufacture. Soft worsted rags of any kind—old stockings or soft cloths made from long-stapled wools—are cleansed and torn into soft fluff in a machine resembling the willow.

The fibres are spun in the usual way and made into cheap cloths. A famous manufacturer has contended that manufactured wool or shoddy is better for making superfine broadcloths than raw wool. In general, however, shoddy is short in staple, brittle and unreliable, and must be classed as an adulterant when mixed with wool.

Mungo. This is an *inferior* shoddy, made from hard, felted, woollen cloths. The short fibres of the cloths are still further broken in the tearing process. Mungo is therefore of little

textile value; but when mixed with low-class wools, it makes cloths of fairly good wearing quality.

Extract. Extract is the lowest possible form of textile fibre. The bulk of it is obtained by consuming with sulphuric acid the cotton warp out of mixed goods or unions, as they are called. The woollen residue is extract.

No animal has a wider geographical distribution than the sheep. Protected by its woolly coat, it roams over Iceland in the north, India and Australia in the tropics, and Patagonia in the frigid south. It feeds on grasses, heaths, mosses, and the tender shoots of many trees. Lands otherwise useless will feed sheep; sheep can live anywhere except on the dry desert, or on the still more barren snowfield. Like all other animals, the sheep is modified by climate and feeding, so that the sheep of the Rocky Mountains bears little resemblance to the Cheviot. But, however much they may differ in size and superficial appearance, all true sheep give wool.

CLASSES OF WOOL

Though not more than a tithe of the sheep breeds supply wool to the world's markets, the variety of wools on the Exchange is large enough to tax the skill and experience of the most expert wool buyer. To the British markets, at London, Bradford, Leeds, Huddersfield, and elsewhere, come wools from Spain, Germany, Austria, Russia and France, in Europe; Cape Colony and Natal, in South Africa; Port Philip, Sydney, and Brisbane, in Australia; from New Zealand, India, and South America. In addition, the United Kingdom itself annually produces a clip of over 140,000,000 lb. of different classes of wool.

Russian wools, owing to the width of the territory covered by the name, comprise many varieties, from the soft curling ringlets of the Astrakhan to the short felting wool of the Iceland sheep. The chief contribution of Spain, sadly diminished of late, is derived from the famous merino sheep, the progeny of which, in Saxony, Silesia, and Australia, now produce the finest wools. The merino is a large sheep, its whole skin, from the tip of the nose to the end of the tail, being covered with a soft, fine wool, averaging from three to five inches in length. Political and social unrest have now impoverished Spain, and the breed of sheep there has deteriorated. Early in the nineteenth century, the sheep-breeders of Saxony and Silesia imported Spanish Merinos, and by careful breeding improved the stock. As a result, those provinces give names to the highest qualities of wool.

The fineness and lustre of the wools of Germany and Austria have greatly assisted woollen manufacturers to produce cloths equal to mohair and alpaca. Closely rivalling the wools of Saxony in quality, Australia sends large quantities of wool to the home markets. In 1798, Captain Macarthur, with commendable foresight, introduced a small flock of merino sheep, three rams and five ewes, and succeeded in acclimatising them, with the result that the breed spread all over the Australian continent. Despite droughts of phenomenal severity, the sheep-breeding, wool-producing industry has flourished in Australia, and in the year 1904 the Commonwealth sent to the London market wool to the amount of over 200,000,000 lb.

French wools are chiefly remarkable for their purity of colour, French wool-growers having to compete for the custom of their own dyers, the most fastidious colourists in the world.

Argentina is the largest South American exporter of wools to this country. Though equal in quality to the best British wools, the fleeces are dirty, irregular, and unreliable. Alpaca and vicuna come from Peru and Bolivia.

Cape Colony bids fair to become, in the near future, a kind of universal provider to the wool consumer. Mohair, alpaca, merino, and the native fat-tailed sheep seem equally to flourish in South Africa. At present we derive from that region about 70,000,000 lb. annually. The wools of India are crisp, deeply serrated, short, and strong, indispensable to the manufacturers of felts and carpets.

British Wools. The large variety of British sheep breeds has been, with difficulty, divided into two classes—long-woolled and short-woolled—by writers on the subject. Practical men, however, do not accept the classification implicitly. A better, though not perfectly accurate, division is given under the terms carding and combing. Carding wools are short, serrated, of good felting property, and used in the manufacture of woollen cloths. Combing wools are the raw material of the worsted manufacturer, and have fineness, length, lustre, and elasticity as their main qualities.

Lincoln, Leicester, Romney Marsh, and Blackface sheep produce the bulk of the combing wools; the Shropshire, Oxford, Hampshire, Norfolk, and South Downs, and Welsh and Shetland breeds yielding carding wools; Dorsets and Cheviots may be grouped in either class; Lincoln wool is long, lustrous, silky; Leicester, fine, elastic, lacking in softness and lustre; Blackface, long in staple, coarse in fibre, suited for heavy cloths; Cheviot wool is fine, soft, of good colour, and medium length; Dorset is weaker than Cheviot, but otherwise similar in character; Shropshire Down gives the best carding wools, clean, lustrous, flexible, and of good felting property; Norfolk ranks next, the wool being highly valued for general textile work; Oxfords and Hampshires, long-stapled, but coarse, suitable for rough woollens, carpets and flannels; South Down wool is fine, but harsh and brittle. Welsh wool is lacking in curl and fineness, but serves to make good flannels. Shetland wool, curling, but deficient in serrations, almost hair-like, makes a good knitting wool, and some hosiery manufacturers specialise with it.

These classifications profess to be no more than pointers, and as such afford the student useful guidance. But sheep farmers are constantly improving the flocks, crossing one breed with another, and importing fresh strains, so that the classifications of yesterday are unreliable to-day.

To be continued

A SHORT DICTIONARY OF THE TEXTILE TRADES

ABB—Woof; fleece skirtings.
Abbwool—Warp yarn.
Alpaca—Cloth from wool of Peruvian sheep.
Angora—Cloth from Angora goat wool.

BALE—Package of cotton, wool, or other raw fibre.
Baling—Pressing cotton or wool into small bulk.
Band—Cord of spinning spindle.
Bank—Bobbin frame.
Beam—Wooden cylinder on which warp is wound in loom.
Beaming—Winding warp on beam.
Beating—Opening and cleaning textile fibres
Bengal—A striped muslin.
Binder—Lever of shuttle-box.
Bink—Mass of cotton ready for mixing
Blind-weaving Loom—Loom with wide warp
Blower—Machine for spreading textile fibres
Bobbin—Spool headed at both ends for holding yarn.
Bobbin and Fly Frame—First machine in spinning process, see slubbing, roving, drawing, &c
Bobbin-lace—Lace made by unwinding thread from bobbins on to pins stuck in a pillow, according to pattern.
Bobbin-stand—Frame holding bobbins from which warp is formed
Bobbinet—A net lace
Bolster—Sleeve of spindle in spinning frame
Bolt—Narrow roll of cloth.
Bombazin—Fabric of mixed silk and wool
Border—Selvage.
Borders—Narrow cloths and laces.
Brattice-cloth—Heavy canvas for mine ventilators.
Breaking—Forming wool fibres in long lengths.
Breaking—Shortening flax fibres
Breast-beam—Cloth beam on a loom
Broadcloth—Fine woollen cloth over twenty-nine inches wide.
Brocade—Silk fabric ornamented with silver or gold
Brussels—Kind of lace, imitating Brussels point; carpet.
Buck—Bleaching liquor; linen in first stage of bleaching.
Buff—A strong rough felt.
Bundle—60,000 yards of flax yarn.
Buntine—Printed cotton.
Burlap—Wrapping canvas made of flax, hemp, or jute.
Burling—Picking threads and knots off cloth.
Burring—Removing foreign vegetable matters from textiles.
Burr—Waste of raw silk.

CALENDER—Smoothing and pressing cloth.
Cambric—Fine white linen cloth.
Camlet—Rough cloth of camel's hair; fabric of mixed wool, cotton, and silk, with wavy surface.
Can—Tin cylinder holding slivers.
Canton flannel—Cotton flannelette.
Card—Machine for disentangling and ranging textile fibres, lap or sliver of carded fibres.
Cards—Perforated slips of card used in the jacquard apparatus.
Cashmere—Wool of Tibet goat; a fine worsted cloth.
Chainwork—Hosiery fabric.
Checks—Pattern made by crossing warp and weft of different colours.
Chinchilla—Woollen imitation of Chinchilla fur.
Chine—Fabric woven with variegated and mixed yarns.
Chintz—Fine quality of printed calico.
Chip—Straw plait.
Cleaner—Silk brushing machine.
Clearer—Rollers in carding machine.
Clearer—Silk fixer.
Clearing—Whitening unprinted part of calico.
Clew—Thread of warp or yarn.
Clewing—Straightening warp threads.
Clip—The whole wool of a flock; the act of shearing.
Cock-a-bendy—Tool for twisting ropes by hand.
Comb—Machine for separating fibres of textiles
Comb—Hat former.
Condenser—Set of oscillating rollers for reducing the sliver
Cop—Small cylinder on which yarn is wound
Copping-rail—Bobbin rest on the throstle spinner
Cord—Fabrics with corded surface
Cording—Setting the heddles, or healds, in the loom
Cram—Close warp.
Crewel—Two-thread worsted
Cut—A length of yarn, 300 yards

DAMASK—Figured linen
Damper—Humidising or spraying machine
Devil—Rag tearing machine, fibre cleaning machine
Diagonal—Twilled woollen cloth
Diaper—Small cloths with damasked figures
Dimity—Strong cotton fabric, corded
Discharge-style—Method of calico printing
Dividing-sinkers—Apparatus on knitting machines
Doffer—Comb or cylinder at end of carding machine.
Doubles—Shoestring ribbons woven from doubled warp
Doubling—Spinning or twisting strands of yarn into one
Draught—Arrangement of the healds or heddles
Drawing—Putting the warp through the heddles
Draw-boy—Boy who pulls warp threads in harness weaving.
Drawing-frame—Machine by which textile threads are attenuated.
Drawing-roller—Fluted roller of the drawing frame
Dressing—Strengthening yarn with starchy substance
Drill—Heavy twilled cotton fabric
Drop-box—Shuttle-box automatically delivering shuttles as required.
Dunging—Removing superfluous mordant by dung.

EDGING—Narrow lace.
End—Sliver, thread, carding; worsted yard in Brussels carpet
Extract—Woollen material derived from union cloths.
Extractor—Centrifugal drying machine.

FANCY—A cylinder on the carding machine
Feed-cloth—Apron leading fibres into machinery.
Fell—End of web
Felt—Cloth formed by beating fibres together.
Fine-drawing—Sewing up faults in a weave.
Fingering—Thick worsted yarn combed out.
Finishing-card—Last carding-machine in a series.
Flannel—Soft, unshrinkable, woollen fabric.
Flax—Raw material of linen.
Fleece—Wool of one sheep.
Flyer—Double hook bent over bobbin on spinning frame.
Flyer-lathe—Horizontal beam which beats weft into warp.
Floats—Threads crossing without intersecting warp.
Floor-cloth—Textile fabric painted over.
Floss—Ravelled down off the silk cocoon.
Fly-shuttle—Shuttle mechanically driven.
Footing—Plain lace.
Frame—Head of batten in loom.
Frieze—Rough woollen cloth.
Fringe-loom—Loom on which fringes or fringed cloth is woven.
Frizz—Lift up nap of cloth.
Fulling—Beating cloth to felt threads together.
Fustian—Strong twilled cloth of mixed cotton and linen.

GALOON—Silk, woollen, or mixed braid
Gassing-frame—Machine for burning loose fluff from yarns.
Gauze—Light silk or cotton cloth
Gig-mill—Machine which roughens up the nap of cloth
Gill—Carding of flax
Gill-box—Wool-combing machine.
Gimmer—Ewe over one year old.
Gimp—Silk covered cord
Ginning—Freeing cotton wool from seeds by a machine
Glove—Hatmaker's tool, a flat piece of wood causing nap to adhere to felt
Grasscloth—Cloth made of China grass fibre
Grey Goods—Fabrics in natural colour
Gunny—Coarse jute canvas

HACKLE—Steel pin used for straightening out fibres of flax or hemp
Half-gang—Section of warp
Hank—560 yards of wool yarn, 840 yards cotton and silk
Hardening—Forming felt into hat shape
Harness—Apparatus controlling warp on loom
Hasp—Spindle
Hawser-laid—Rope of three strands of three yarn each
Heck—Guide regulating spun yarns in reeling, warping, beaming.
Heddle—Eyelets in looped cords hung vertically from transverse bars, and used to carry the warp
Heer—A length of yarn, equals two cuts.
Hurdle—Bowing bench of hat-felter
Hydro-extractor—Centrifugal drying machine

INGRAIN—Dye in the wool
Italian—Satinised cotton cloth

JACK—Pivot bar of knitting machine
Jack-sinker—Plates moving on jack to form knitting loop.
Jack frame—Sliver twister.
Jean—Twilled cotton cloth, sometimes mixed wool and cotton.
Jigger—Felting machine.

KEIR—Bleaching vat.
Kemp—Hairs among wool.
Kersey—Ribbed cloth of long staple wool
Kerseymere—Light woollen twill with oil finish.
Kidderminster—Double warp cloth carpet.
Knitting-burr—Winged wheel acting on yarn in knitting machine.
Knotting—Picking out knots in cloth.

LADE—Channel of water-power.
Lambskin—Woollen imitation of dressed lambskin.
Lap—Web of carded wool.
Lapper—Cloth folder.
Lapping—Blanket of calico-printing machine.
Lash—Thong binding warp cords of Brussels carpet.
Latch—Hinged hook of knitting-needle.

Lathe—Wooden frame driving weft into warp.
Lattice-carrier — Endless belt of wooden strips carrying cotton.
Lay—Of cotton, 120 yards; linen, 300 yards; rope, the style of laying the yarns.
Lay top—Conical block of wood kept close to the twisting point of rope yarns.
Lead-sinkers—Complement of jack-sinkers.
Lease—Band round warp sections.
Lease pins—Warp dividers.
Lease rod—Lath holding warp bands apart in loom.
Leasing—Keeping warp threads on one plane.
Leashes—Cords of the jacquard; the heddles.
Let-off—Warp beam regulator.
Levantine—Fine silk cloth.
Licker-in — Small roller working on carder between feeder rollers and main cylinder.
Lifting-bar—Holder of lifting blades of jacquard
Lifting-wires—Wires of jacquard apparatus.
Linen—Cloth made of flax or hemp
Linen-prover—Microscope
Linoleum Cloth canvas covered with prepared linseed oil
Linsey-woolsey—Cloth of mixed linen and wool
Lint—Flax thread, softened linen for bandages.
Liquor Solution of dye or mordant
Lisle—Fine lace
List Binding border of web
List Woollen flap of the ropemaker
Llama Wool of the llama.
Long-wool—Combing wool
Loom Weaving machine
Loop-cutter Blade at end of looping wires.
Looping wires Wire forming loops of tapestry carpets, velvet and plush pile
Lustre—Highly finished cloth of cotton warp and woollen weft

MACRAME lace Lace made from twine
Madder style—Printing calico with mordant.
Mangle Calendering machine
Matting Fabric made of flax, coir, jute, by plaiting or weaving
Mercerise Giving textile fibres a gloss.
Merino Wool of merino sheep
Merino Fine dress cloth made of merino wool
Mixtures Cloth made of mixed yarns
Mordant Metallic salt fixing colours
Mountings—Pattern forming apparatus of the loom
Mule Spinning frame which draws and twists rovings.
Mungo *Cloth made of fibres derived from old woollen rags*

NANKEEN Cloth made of yellow cotton.
Nap—Fine hairy surface of cloth, pile of velvet or plush.
Needle-loom—Loom in which a needle serves for shuttle.
Needle-warp—Additional warp, passed through needles set on a transverse lath
Net—Lace formed by netting
Netting—Twining two ropes into one.
Nipper—Rope-tarring gauge
Noils—Waste from combing machine

OPENING—Loosening textile fibres.
Organzine—Thrown silk.

PACK—About 240 lbs. wool
Packsheet—Coarse cotton, flax, or jute cloth covering for bales.
Packthread—A cotton or hemp twine.
Padding—Covering calico with mordant.
Pattern-box—Box delivering shuttles according to pattern.
Persian Light silk.
Persian Carpet—Carpet with linen warp and tufts of wool for weft.
Patent Axminster—Imitation Persian carpet.
Pick—A thread of weft.
Picker Fibre cleaner; shuttle driver.
Picker-peg—Wooden or leather peg that strikes the shuttle.
Piece—10 yards muslin, 28 yards calico, 26 yards linen.
Plaiding—Woollen goods of check pattern, generally heavy cloth.
Planking—Forming hat bodies.
Plough—Nap cutter.
Plucker—A kind of carding machine for combing wool.
Plush—Cotton velvet.
Ply—The number of yarns in a thread.
Point—Lace worked with the needle.
Points—Needles in a knitting machine.
Print—Calico printed.

RADDLE—Warping guide
Reed Two-sided comb of brass wire, set in the loom lathe to beat the weft into the warp
Reeding Putting the warp through the reed
Reel Core on which fibres, yarns, threads, or cloths are wound
Rep Corded fabric
Resist-style Method of calico printing
Ribbon Narrow web
Ring-spinner Spinning machine drawing and twisting thread by ring or disc
Rock Hand spinning staff
Rope Cord made of cotton, flax, hemp jute, and wire
Rovings Slivers reduced by drawing and twisting for spinner
Rug Rough woollen fabric

SARCENET Plain silk ribbon
Sateen Imitation satin
Satin Smooth, bright silk cloth
Scarf-loom Narrow loom
Scribbler—First carding machine
Scrimping bar—Regulator of the feed to a calico printing machine
Selvage Strong edging of web
Setting Placing the printed warp of tapestry carpets.
Shed Space between the upper and lower halves of the warp
Shearing Cutting the nap of fabrics even
Sheeting Common calico
Shoddy Cloth made from worsted rags.
Shot A single thread of weft.
Shroud-laid Rope made of four strands
Shuttle Wooden boat carrying the weft cop across the warp
Singeing *Removing the fluffy nap in gassing*
Size Glutinous substance for dressing yarns.
Sleave Tangled silk.
Sliver—Soft rope of fibre formed on the carding machine
Slubbing Reducing sliver to uniform size
Snick A knot.
Souring—Steeping calico in dilute solution of sulphuric acid.
Spindle—Rod axle of revolving spool, cop, or bobbin
Spindle A length of yarn of different length in different fabrics
Spinning—Drawing out fibres into thin threads.
Spoon—Automatic stop-motion of the drawing frame
Spots—Fancy spotted muslins.
Spreader—Flax carder
Staple Lock or tuft of fibre.
Stocking-frame—Knitting loom.
Stocks—Fulling or felting mill.
Stoving—Drying in hot air.
Strands—Twisted lines of which a rope is formed.
Straw plait—Material of straw hats.
Stretcher mule—Spinning frame for fine yarns.
Stretcher—Lace drying machines.
Stripping—Clearing the carder.
Stripes—Alternately coloured fabric.
Strop—Double-eyed rope for twisting strands.
Stuff—Commercial name for fabrics.
Sun hemp—Low quality hemp.
Surah—Silk.
Surat—Indian cotton of a coarse kind.
Swansdown—A fluffy cotton cloth.
Swifts—Reel for hanking yarn.

TAB—Arm of the fulling stock.
Tabby—Watered silk.
Take in—The motion of the cloth beam.
Tambour—Embroidery or fancy weaving apparatus.
Tape—Narrow fabric.
Tapestry—A light kind of carpet.
Tanty—Hindu loom.
Tartan—Woollen cloth of crossed and chequered patterns.
Tatting Making a kind of lace
Teasling—Ruffling up the nap of cloth with thistle burrs
Tenter—Loom mechanic
Tenter frame—Frame on which fabrics are stretched and dried.
Tew Pressing
Thirl Bind or tie
Thread Twisted yarn, sewing cord.
Thread frame Doubling and twisting mill
Throstle Ring spinning frame
Throwing Spinning and combining silk yarn
Thrums Weft ends and broken warp
Tow Tuft of fibre
Towelling Coarse linen cloth.
Tram Silk weft
Tufted carpet Patent Axminster
Tweed Light twilled woollen fabric.
Twill Fabric having the warp and weft twilled
Twine Turning fibres or yarns round each other
Twisting Forming one thread from several strands of yarn by twining them

UNION Cloths made from mixed yarns cotton wool, etc

VALANCE Silk fringing
Valenciennes Lace of hexagonal pattern
Veiling Fine lacy fabrics.
Velure Smoothing and lustring the silk hat
Velvet Silk pile fabric
Velveteen—Cotton imitation of velvet.
Venetian *A kind of warp raised carpet*
Vicuna *Cloth made from wool of Bolivian sheep.*

WALK-MILL Fulling mill
Warp—Threads on which the weft is woven to form cloth
Warp beam—Roller holding the warp
Warping—Winding the warp from the yarn bobbins.
Waste—Broken fibres useless for spinning
Weaving—Crossing warps by weft on a loom.
Web Fabric woven.
Weft—Thread crossing the warp.
Willow—Machine for cleaning textile fibres.
Wilton—Velvet pile carpet.
Wincey—Cloth made of cotton warp and wool weft.
Winding—Coiling yarn on a bobbin or cop.

YARN—Spun fibre.

IDEAS

A SHORT SURVEY OF THE WORK OF AN IDEA IN THE WORLD

AND

THE GREAT OPPORTUNITIES AWAITING BRAINS IN MODERN INDUSTRY

SHOWING THE POWER OF IDEA IN

Trade	**Crafts**	**Warfare**	**Industry**	**Architecture**
Science	**Invention**	**Medicine**	**Music**	
Building	**Finance**	**Travel**		
Books	**History**	**Painting**	**Exploration**	

FOLLOWED BY STUDIES IN

APPLIED EDUCATION, THE UTILISATION OF KNOWLEDGE IN EVERY WALK OF LIFE

BY

ERNEST A. BRYANT, F. L. RAWSON, and HAROLD BEGBIE.

A GREAT IDEA, THE PRICELESS ASSET OF THE WORLD

By Ernest A. Bryant

THE world is ruled to-day, as it ever has been ruled, by the men of ideas. Behind the thrones of the great Powers they stand, directing the hand which nominally wields the sceptre. In the great republics the men with ideas are they whom the nations choose. In all lands where government is pure and for the greatest good of the greatest number, the high offices of State are held by the men with brains.

Lineage and academic distinction shrink to insignificance in the fires of modern competition. Were it otherwise we could not have seen the scion of a village postman upon the Papal throne; the descendant of a line of peasants at the head of the French Republic; or a man who began life on a small railway negotiating matters of the most vital importance to Russia. The possession of ideas has become a man's richest asset, provided always that he has the practical turn of mind rightly to apply them.

The Birth of an Idea. No man can command the birth of an idea. They come and they go, these will-o'-the-wisps of fancy, and no man knows whence nor whither. Their advent may be wholly without the volition of the brain in which they are born; it is for the brain to see to their retention and use. Men's minds vary in degree of receptivity and retentiveness, as one photographic plate differs from another. For one plate the merest glimpse of light enables it to record an object within its focus, no matter how swiftly that object move; the other needs long exposure and steady light before an impression can be received. Both plates are essential to the photographer's art; the one for rapid movement, the other for still life, dim interiors, and every item of detail.

So it is with men. To some, ideas come, complete in every particular, like an inspiration—a melody which shall sound throughout the world, a revolution in mechanics, in locomotion, in abstract science. Another man, the movement of whose mind no stimulus can accelerate, assimilates an idea by laborious mental process, but brings it in the end perfect to its work. So we find the broad line dividing the genius from the plodding, unwearying thinker, the poet from the cautious philosopher; the Browning from the Gray; the Macaulay from the Herbert Spencer; the Edison from the Singer; the man of a myriad schemes from the man of one grand idea, slowly and with vast effort won from nebulous gleams to coherent reality.

Ideas in History. Life runs so smoothly now, that originality, the superficial think, cannot possibly deflect its course to ways still smoother. So the superficial thought in all ages, deriding and persecuting the pioneers of change. But history teaches that the revolutionary and the visionary of to-day in science, in commerce, in politics, are apt to be found least advanced among the men of to-morrow. The discovery of the possibilities in steam accomplished a greater advance for civilisation than anything previously done for the improvement of locomotion from the beginning of time. Sir Robert Peel, on forming his first ministry, travelled from Rome to London to assume office as Prime Minister, exactly as Constantine had travelled from York to Rome to become Emperor. Each traveller had all that sails and horses could do for him, and no more. A few years afterwards the humblest steerage passenger had at his disposal the means of reaching Rome from London within a few hours. It was the result of an idea.

The basis of the idea was not new. Nigh upon two thousand years before, Hero, the mathematician of Alexandria, had designed the first steam engine. It was an idea which enabled Napoleon to throw an army—horse, foot, and

artillery—across the Alps, and, sweeping like a hurricane down upon Italy, lay her conquered at his feet. Here was another idea which had lain dormant since two hundred years before the dawn of the Christian era, when Hannibal, with horses, elephants, and 90,000 men, crossed, first the Pyrenees, and then the Alps. A new idea in naval attack gave Nelson the victory of the Nile, and enabled him to sweep the French and Spanish fleets from the sea. So fertile of resource was he that even to-day the naval critics are not agreed as to whether the victorious plan at Trafalgar, so striking and daring, was that with which he originally contemplated the battle.

Haphazard Revolution. Enough, however, of warfare. Our purpose is more pacific. There is no phase of life in which the fertile mind does not lift its master above his fellows. Sir William Harcourt and Lord Goschen would live in the history of statesmanship had they never done aught beyond their work as Chancellors of the Exchequer. Sir William Harcourt's Death Duties, although denounced at the time by those most affected, have proved one of the greatest reforms in national finance; and Lord Goschen's conversion of the National Debt was a signal achievement for one man's mind. Once accomplished, reforms such as these seem the most obvious solutions of the difficulties which disappear before them. But it is the fact which stares one in the face, so to speak, which most frequently is overlooked. Year after year surgeons practising in all the cities of Europe contrived, by operations, more or less to relieve affections of the ear. One day an accident occurred; a Viennese surgeon made too deep an incision and cut the bone. By a happy mischance a new and important operation was discovered. He seized the idea. Years of experience had failed to impress him with the obvious advantage thus forced by accident upon his notice.

Ideas are begotten, very often, of suggestion. There are suggestions everywhere for the eye which sees. Nature is still the great teacher if we can but read her lessons. What relation can there be between a tree and a lighthouse; between a leaf and a revolution in architecture? Monumental record exists to-day of a very close connection. The Eddystone Lighthouse, which has braved the fury of the waves for more than a hundred years, is modelled on the trunk of a tree. Winstanley's lighthouse had been destroyed by a storm, and Rudeyerd's by fire, when John Smeaton undertook to erect a successor. So narrow was the ledge of rock upon which to build that he determined the only course was to root his building after the manner of a tree. Just as the trunk is held in place by its roots deep down in the ground, so the foundations of the new Eddystone were sunk in the excavated rock, and fastened there by an ingenious dove-tailing. The Eddystone still stands, strong, immovable as ever, the model upon which all subsequent lighthouses in similar situations have been built.

The Crystal Palace from a Leaf. The Crystal Palace, with its light, graceful, yet strong design, we owe, not to an architect, but to a gardener with ideas—Joseph Paxton. No man in England was able to furnish plans to meet the requirements of the building for the Great Exhibition, the purpose for which the Crystal Palace was constructed. Defects spoilt the most promising. Paxton overcame the difficulties. He had found his idea in his garden. An examination of the fine plant the Victoria Regia had shown him the wonderful power of flotation possessed by its leaves, and the principle upon which this was contrived. What a plant could do, a man could imitate. The old and unsightly heavy ties and girders which architects had always been accustomed to employ were unnecessary. He showed by homely illustration the effect of his plan. A splinter of wood may be easily snapped if its ends be pushed towards each other; but a great force is required to pull the ends asunder. So iron and glass came to take the place of wood and stone, and a new system of building was introduced—by a gardener.

Brunel and the Worm. From such insignificant sources do great creations spring. In the dust of the earth, in the industry of a worm, in the colours of a soap-bubble, the great mind finds that which aids him some way further to read the writings of eternal laws. This is no mere flight of fancy. In the very dust is an exquisite story of the marvellous provisions of Nature to give shadow and tint; in the soap-bubble Newton found that which gave it a legitimate place among the most curious of optical phenomena. And the worm? It taught us sub-aqueous tunnelling. From the beginning of history the teredo or pholas, the soft white worm which lives in our harbours and the mouths of rivers, had pursued its destructive course, boring its way through the hulls of ships, eating the defences of harbours. It had even brought a whole country to the verge of ruin, when it so perforated the piles upon which Holland relied for its defence from the sea. No man had seen a virtue in the worm, none had been able to glean an idea from its wonderful work. Then there came Brunel, who, watching its operations, saw how he might construct his tunnel beneath the Thames. The worm, he learnt by close watching, encased itself in a calcareous tube of masonry as it bored its way into the timber. Here was the fountain of his engineer's idea. He set men to bore with rods into the mud from a shield, which was moved forward as they made their way, and a brick arch constructed in the rear, in exact imitation of the calcareous tube of the worm.

How a Great Breakwater was Built. So the seeing man finds his inspiration. Lessons such as these are everywhere to be gleaned by the observant. Take another instance, not less romantic. The engineers who built the mighty breakwater at Cherbourg noted with what strength common mussels cement themselves together, adhering to rocks and stones or any solid substance which happens to lie about them. Taking advantage of this knowledge, they saved themselves the trouble of extending their sub-

marine masonry indefinitely. They deposited in the sea at the proper places huge quantities of loose stones. Upon these they tipped tons of live mussels, knowing well that the shell-fish speedily would spin their string-like webs and so bind together the stones with a cement more durable than any man could make.

Paxton was not the only man of his generation who knew the mechanism of the Victoria Regia; Brunel was not the first to observe the process by which a soft, gelatinous worm made its way through oak timbers; their knowledge on these subjects was commonplace to the botanist and the naturalist. It was the application of the idea which was startling. Ideas occur to man after man in successive generations and are wasted, until there is fashioned the mind which is productive as well as assimilative. Men recognised and sorrowed over the evils of slavery, but none stretched forth a hand to help until there came a Wilberforce into the world to thunder forth "Emancipation!" Men saw and deplored the ignorance of the masses, but waited for Gladstone to remove the tax on newspapers. The hardship which the heavy cost of the carriage of letters entailed upon the poor was manifest to all, but the proposal of the penny post came like a bolt from the blue.

The Application of Ideas. How can ideas be applied? That depends largely upon the circumstances of the individual and the nature of his scheme. There never was a better time than now, when greater scope was afforded for the carrying out of new projects. "The men for whom we look now with a view to possible partnerships are no longer those with capital," a prominent member of the House of Commons said to the writer. "We must have men with ideas capable of adequate expression in practical production." One man, a working plumber in a Kentish village, devotes his leisure at nights, and the scanty holidays granted him, to materialising ideas which occur to him in odd moments during his work. A year of nights he sacrificed to the fashioning of an appliance for soldering—a tiny mechanism which he carries in his waistcoat pocket—lamp and blowpipe combined, which enable him to dispense with the cumbersome brazier and melting-pot. Such a man with increased opportunities might prove a second Nasmyth, and give us a contrivance as important as the hammer with which the name of that genius is associated. The villager's inventions are his voluntary creations: Nasmyth invented his Titanic hammer in response to the appeal of a man who could not otherwise get a forge hammer capable of producing the shaft which he needed.

As a rule, however, inspiration is an unwilling and unstable guest; it must be seized at once, before it may be too late. Coleridge dreamed his "Kubla Khan," and wrote in his waking moments the precious stanzas which he remembered. John Bright composed all his speeches in bed. Most of us, however, must look to periods of great mental alertness for the coming and thinking-out of ideas. And when they dawn upon our horizon, they should promptly be noted down.

An Industry in a Village Stream. There may be value in the flimsiest notion. A man thinks of a metal tip for boots, and makes a fortune from it; another applies a piece of rubber to the end of a pencil. A third compounds a decoction which, smeared upon windows, prevents their "steaming" in cold weather. Another, of scientific bent, notes that a mineral refuse, thrown away as valueless, emits a strong odour when in contact with water, and the result is acetylene gas and all that that may yet mean as an illuminant. A certain stone yields its secret to a person who by the proper process converts it into an enamel for making earthenware and china non-porous. The sands of the sea become an asset to him who discovers their use for the making of incandescent mantles. A trickling stream of mineral oil in a Derbyshire mining village was found by Lord Playfair to contain paraffin, and from his recognition of its worth sprang up the gigantic industry which has made fortunes in America such as the world before had never known. Every invention opens out fresh fields for other inventions, and the examples we have seen may stimulate thought in directions in which advance may still be made. Man sails the air and sails the seas; and hastens with the speed of the bird upon dry land. But in each phase of travel he is anxious still to do better. The electric train supersedes the steam-engine. The turbine steamer ousts the older form, just as the screw propeller gained the day against the paddle-wheel. Electricity and the motor claim the sphere of the horse for individual travel by road.

The Old World and the New. These are among the ideas newly utilised. The men in whose brains they took shape perform more notable service for mankind than the greatest general who ever slew a rival's forces. The compositor who sets up the type for the Bible, and the machinist who prints the pages, are greater forces for good than the wisest of the ancients. Those wise men of old, in the dim light which preceded the glow of learning whose glorious dawn our own day was to witness, had their splendid and noble ideas; ideas which live in architecture at which the world still marvels and cannot emulate. With their manual labour and their implements of which the world has lost count, they fashioned their wonderful Sphinx, which, in spite of all that has since been achieved, remains the greatest stone monument in the world. Their enamels have outlived the shells and rockeries of which they were but the veneer.

But the modern idea brings mightier things to pass than ever those wise men of the East could dream. We bridge rivers and straits and gorges which would have been impassable to them. We send flotillas of mighty ships where they had not a waterway. We print in an hour fifty thousand papers, one copy of which it would have taken them a lifetime to write. We navigate seas which were to them unknown; and we race at sixty miles an hour over lands whose existence was to them unimaginable.

To be continued

CIVIL SERVICE

A GUIDE TO EVERY BRANCH OF PUBLIC SERVICE IN THE BRITISH EMPIRE

DEALING WITH

MANY THOUSANDS OF POSTS IN THE MUNICIPAL, NATIONAL, AND COLONIAL SERVICES

FOR

Clerks	Tramway Managers	Solicitors	Electricians
Engineers	Poor Law Officers	Surveyors	Draughtsmen
Accountants	Officers of Health	Interpreters	Telephonists
Architects	Revenue Officers	Inspectors	Telegraphists
Chemists	Post Office Officials	Attachés	Police Officers
Firemen	King's Messengers	Ambassadors	Prison Officials

WITH ALL ESSENTIAL INFORMATION CONCERNING THEM, GATHERED FROM OFFICIAL SOURCES

BY

ERNEST A. CARR, of H.M. Civil Service

THE GREAT ORGANISING ARMY OF THE NATION

By Ernest A. Carr

ENERGETIC, capable, ambitious young men and women whatever their training or social station who are in quest of a life work that offers interesting duties, liberal rewards, and a wide scope for their abilities, will be wise to consider carefully the claims of our Civil Service as a career.

The expression "Civil Service" is technically used sometimes to denote only the staffs of Government offices, but by right of origin the word "civil" means "pertaining to the citizens and the State." It is in this wider and more natural sense that we use it here. The "fighting services," as a matter of convenient arrangement, are separately dealt with elsewhere (see ARMY and NAVY), and with purely honorary posts our readers are naturally not concerned. Excluding these divisions, the term Civil Servant means for us every salaried, non-combatant officer engaged in the administration of public interests, whether strictly local or affecting the whole Empire.

A Civil Army. It is clear that a huge variety of posts, and of public bodies, is included in this definition. The officials of the smallest District Council or Board of Guardians are Civil Servants, no less than the First Lord of the Treasury or the Secretary of State. From the village lamplighter or the park policeman to our ambassador at St. Petersburg, from the political agent in some half barbarous Indian state to the telegraph messenger in Fleet Street, runs the linked band of public servants by whose united efforts the great business of the British Empire is carried on.

The numbers of this civilian army, its diversities of status, work and pay, defy calculation. In London alone its members form two army corps—10,000 more men than stood in the ranks of the Allies at Waterloo. Every industrial centre has its regiment of public servants, each small town its picket, each village at least a sentry; while lonely outposts keep watch in every corner of the globe where British rule holds sway.

Within these wide limits is room for all grades of education and all varieties of gifts. The learned, scientific, and technical professions are represented by thousands of well-remunerated posts. Clerks and bookkeepers of every rank form, as it were, the main infantry force. The practical expert and trained mechanic find in the Civil Service a ready market for their skill, and there are countless intermediate, special and minor posts besides. To analyse and classify this medley of appointments is the business of the articles that follow; our concern for the moment is with the claims of the service as a whole.

Attractions of the Service. If a popular vote were taken as to what constitutes a satisfactory calling, the first essentials agreed upon would probably be that the work should be well paid, permanent, and with some security of tenure; free from offensive or unduly arduous conditions, and offering advancement in proportion to merit and experience, with scope for personality.

Widely as the conditions of employment vary within the huge and complex machine of the Civil Service, it will certainly be found, when tried by such commonsense standards of value as these, to compare favourably with other callings. It cannot, in the nature of things, offer the fabulous incomes of our foremost singers and actors, or the first flight of "counsel learned in the law." The man whose superlative talents demand a five-figure salary should avoid the public service, unless he is within easy reach of the Woolsack. More modest ambitions, however, may secure incomes in the Civil Service averaging distinctly higher than in the unofficial world. The "sweating" employer has no counterpart in the Civil Service, which aims at securing efficiency by selecting its officials with care and paying them well. Public officers, as a class, are liberally though not extravagantly remunerated, with salaries progressing either by regular increments or according to personal merit. Generally these two systems are employed in combination.

Permanence and Security. The permanence and security of Civil Service posts are two of its most attractive features. Their

holders, unlike many private employees, cannot be dismissed save for serious misconduct or default; and, except in the Government workshops and similar fields of employment, their earnings are unaffected by "bad times." When, as occasionally happens, the remodelling of a department leaves no room for a former member of the staff, he is usually transferred elsewhere; or, should the change compel him to resign, he is liberally compensated for his loss of office. But such incidents are rare. The public official with a good record is normally secure for life.

Work Well Paid For. Nor need he be apprehensive of overwork. The day of "snug sinecures" is past, and Civil Servants must give a reasonable equivalent for their salaries. But the practice is to maintain a staff fully adequate for ordinary needs, and to reward with special grants or increase of salary any pressure of extra work which cannot be avoided.

These "perquisites" are sometimes of great value. An official acquaintance of the writer's, for instance, supplements his salary of £400 to the extent of £80 a year by occasional translations of office documents; another, whose salary is £225, recently earned £70 in six months by special evening duty. Almost the whole clerical staff of one busy Government office draws "extra duty pay" every year, varying from £30 to £100, according to rank. In municipal employment the rewards for special services are more liberal still. For extra work in connection with the electrification of a borough tramway system, an engineer received not long ago an honorarium of £200; and for a like reason the engineer to another corporation was granted a special payment of £750. Extra work among Civil Servants is welcomed rather than shunned.

Promotion. The question of promotion is complex, dependent on varying conditions. Chances of advancement vary greatly in different offices and in the several grades, but are distinctly favourable on the whole. The Government service, it is true, is hampered still by its traditions, and, while professedly adopting the principle of advancement by merit, it continues to attach too much importance to seniority, and this practice tends to make promotion slower. But the law of seniority is daily disregarded in favour of men of special ability, and is tempered, besides, by the regular increments which automatically raise each official to the maximum salary of his class. In the local services, more frankly modern and democratic, efficiency is the decisive factor, and the scope for a man of energy and capacity is almost unrestricted. The highest commands in this great civic army, as in the armies of the young French Republic, are open to any man in the ranks who can give proof of his strength.

Merely noting in a word the liberal provisions of the Service as to sick pay, leave and pensions, and reserving their detailed discussion, let us turn to consider other attractions which are not to be measured by any commercial scale. Foremost among them must be reckoned, by all who have a thought beyond money, the dignity and usefulness of the public service. This dignity is a quality quite other than the self-importance of officialdom. To take a share, however modest, in the government of the State is a distinction and a privilege. To work for the public weal, to place one's abilities, whether great or small, at the service of no less a master than the City or the State—here is surely a prospect which appeals even to the most practical and humdrum of minds.

Outdoor Life. That the Civil Service is a "noun of multitude," comprehensive enough to furnish congenial employment for almost all tastes and temperaments, will be evident from what has been said. Lovers of an active outdoor life may find their opportunity, according to ability and training, in the foreign, Indian, or revenue branches, or on the non-combatant staff of the Navy. The studious mind will turn towards the higher legal or administrative posts, the man of figures to municipal accountancy and finance, Exchequer estimates, or Government auditing. Science is given scope at our museums, in the service of the public health, and at technical colleges, while its industrial branches are represented by dockyards and telegraphs, by borough engineering and a hundred other activities. The list of special positions for men of particular aptitudes is not easily exhausted.

How are the posts in this great army to be gained? To answer this question clearly and fully, to show how vacancies are filled, what qualifications are needed for each rank, and how such qualifications are best attained, is a task even more essential than that of classifying the great mass of public appointments. To combine these two tasks is the object of this course, the purpose of which is to show, on the one hand, the character and value of every Civil Service post, whether high or low; and to explain, on the other, precisely how each post may be won. The work being primarily addressed to students and prospective candidates for the Public Service, special regard will be paid to such matters as educational standards, professional and other training, competitive tests, examination subjects, and other questions of direct and practical importance.

The Three Great Divisions. For the purpose of a detailed investigation such as this, the great subject of the Civil Service is best divided into three main sections, each of which will be separately considered. We may summarise them as the municipal, national, and Imperial branches of the Service.

The first is a wide and important division, comprising all appointments controlled by the local authorities—whose name is legion—and remunerated from public funds raised for local purposes. Officers of the county and borough councils, of district boards and Poor Law Guardians, of quaint associations like Trinity House, rich and powerful bodies like the City Corporation, and countless minor councils unknown to fame, all fall within this expansive section. The National Civil Service comprises the Government departments, great and small, whose salaries are annually voted in Parliament or paid from State revenues; and, lastly, in the

section devoted to the Civil Service of the Empire, we shall review the various classes of appointment, both municipal and under direct State control, in our colonies and possessions overseas.

The triple series will thus form in conjunction a complete practical guide to the vast field of the British and Colonial Civil Service—a task never before essayed.

THE MUNICIPAL CIVIL SERVICE

The age we live in, witness of so many splendid achievements, has seen nothing more characteristic or more startling than the rapid growth of local government. Scarcely a generation ago this branch of the Civil Service was administered partly by a privileged class with no direct responsibilities to the public, partly by undistinguished local caucuses without any special qualifications for their work. Such a system was naturally regarded by the public with an indifference not wholly free from suspicion. It was widely assumed, sometimes with justice, that public funds in such hands were apt to be wasted, and public interests either neglected through incompetence or sacrificed to private ends. Men of high aims were chary of associating themselves with a service that was "suspect"; shrewd business spirits declined to devote their energies to discussions on the policy of the parish pump.

A few years have sufficed to change completely this condition of things, in part by the agency of legislative reform, but mainly through the development of a sound civic spirit. Side by side with the expansion of the Imperial idea has sprung up a civic patriotism akin to that of the early Greek states. We have learnt to recognise the essential dignity of local administration. Social students and earnest workers of the best type, seeing in it an intensely practical ideal of service, have devoted themselves with splendid ardour to the task; and the municipal system, as a whole, has responded by a degree of activity and efficiency before unknown. Popular confidence in the local authorities has grown amazingly, and has found expression in numerous statutes consolidating and re-modelling their constitution, and greatly amplifying their powers in many directions.

Creation of the Municipal Service. Without wearying the reader with a long list of the Acts of Parliament that have created the modern Municipal Service, we may briefly refer to the foremost among them. The first great measure of this kind, since the days of the Reform Acts, was the Municipal Corporations Act of 1882. This statute fixed the town council in its present form as an elective body of aldermen and councillors headed by the mayor; it defined the powers of the council as to enforcing sanitary laws, lighting the town, and forming a borough police force; and provided for the expenses of administration by the levy of a borough rate. Six years later followed the Local Government Act of 1888—the greatest of the series of reformative statutes, and the creator of the county councils. It was a revolutionary and democratic measure, sweeping away a mass of crusted traditions and abuses, and transferring to the new authorities all duties relating to local government performed until then by justices in quarter sessions. Thus, at one stroke, the control of county finance, rating and assessment, county buildings and lunatic asylums, the registration and polling of parliamentary electors, the maintenance of highways, the prevention of river pollution, and a host of minor powers, were placed in the hands of councils chosen by the county electors.

It was a bold enterprise, and many were the dismal forecasts it evoked. But it was in essence an extension of the policy already developed by the Municipal Corporations Act—the policy of entrusting district administration to an elected body instead of a privileged class. The wisdom of that policy has been amply justified by the event, and particularly by the remarkable stimulus it gave to the country's interest in its own internal affairs. This growing attention to the claims of local government has proved a guarantee of increased efficiency and integrity in the Municipal Service, and has greatly helped to raise the dignity of the Service in public regard.

A later Local Government Act (1894) completed the system of deriving the authority of every local body from the electors. Many measures, both before and since, have added to the activities of such bodies; but the only enactments calling for comment are the Education Acts of 1902 and 1903. They have enormously extended the powers and duties of local authorities in England and Wales by making the council of every county and county borough the education authority for its own area.

The Modern Municipal System. Such are the measures chiefly responsible for the evolution of our municipal organisation of to-day. The system, as a whole, is characterised by bold and effective and public-spirited administration. Its methods are businesslike, scientific and modern, its activities of so wide a range as almost to defy description. In its hands are placed, besides the duties already named, the cleansing and improvements of our streets, the maintenance of water supplies and sewage systems, the protection of the public from fire, the relief of the poor, and innumerable other responsibilities affecting the health and comfort and material welfare of the people. The importance of these functions is literally beyond estimate. Some idea of their extent may be gathered from the fact that local bodies administer every year an income of over a hundred and twenty millions sterling. And as an instance of their bold and successful business methods, it may be added that the net profits from municipal waterworks, gas and electric lighting, and tramways, during the last recorded year amounted to £700,000.

It is only fitting that the responsible men in charge of such enormous and often profitable undertakings should be handsomely paid. Local bodies are ready nowadays to recognise the right of the labourer to his hire; and, instead of a penny-wise policy, they adopt the sounder

economy of employing in each department the best men available, and of paying adequately for their services. The effect of this principle is to quicken the advancement of the capable, and open the gates of a lucrative career to any young man of brains and energy. Napoleon's dictum that every soldier in his armies carried a field marshal's bâton in his knapsack might be justly applied to the official rank and file under our modern municipal system.

Rapid Promotion. A striking instance of rapid promotion in a municipal career is that of the present Clerk to the London County Council. Entering in a subordinate capacity, Mr. G. Laurence Gomme was early advanced to the rank of Statistical Officer at £800 a year; and thence, after some years, by a single stride, to the most responsible position of Clerk of the Council, with a yearly salary of £2,000.

There is another aspect of municipal employment which is particularly noteworthy. Enormously as the system of local government has developed, it is destined to still greater expansion in the near future. Many students of present day tendencies aver that this movement is as yet in its infancy. Whether this is an exaggerated view of its future or not, we cannot fail to realise that the Municipal Civil Service has not reached its full dimensions. It has a great future, not only of to-morrow, but of many to-morrows. To enter it now, in its crescent youth, is to seize one's chance of rising with the rising tide. The growth of a department brings advancement automatically, as it were, to those members of the staff who are worth their salt, as well as furnishing special openings of many kinds.

World's Greatest Local Authority. We may readily illustrate this by reference to the last five years' records of that type and model of administrative efficiency, the controlling body for London. In this interval its activities, and consequently its staff, have developed considerably. Disregarding all promotions, we find that the salaries in respect of the self-same posts have made substantial advances. Thus the Valuer to the L.C.C. receives another £500 a year, the Chief Officer of Tramways a like advance, the Chemist £1,100 in lieu of £800, and the Comptroller's salary has risen from £1,150 to £2,000—all this within five years. Such instances will be many times recurrent in the next decade, and shrewd men will find, meanwhile, in the Municipal Service, that tide in their affairs which, taken at the flood, leads on to fortune.

Not every local authority, of course, can offer adequate careers to its employees. It is true that there is hardly a fair-sized village in the kingdom which does not afford some opening for ability, but the scope of such employment is necessarily very restricted. Only amid the intricacies and responsibilities of administering the affairs of a great town, or a county, can the best men find the best work. Hence there is a steady current of transfers from lesser to more important municipal offices, up to the foremost industrial centres, with London and Glasgow at their head.

A Typical Career. A typical career in this respect is that of Captain Nott Bower, the Chief Commissioner of Police for the City of London. After serving in the Royal Irish Constabulary, he became Chief Constable of Leeds, and next held the important post of Head Constable of the Liverpool police, with emoluments estimated at about £800 a year. Having acquired a high reputation as head of a fine and efficient force, he was next elected to the very responsible appointment he now holds, with a salary of £1,250 a year. His branch of the Municipal Service has but one higher post—the Commissionership of the Metropolitan Police Force, at £2,500 a year.

The system of promotion by transference, illustrated by Captain Nott Bower's record, is so general throughout the Municipal Service as to afford the widest possible field for capable men. Minor and provincial districts are thus a training ground from which leading boroughs and counties recruit their staffs. The best posts in the service to-day are held, with few exceptions, by men who have graduated in smaller offices, and have been translated for distinguished service.

A glance at a typical municipal office in full swing may help us to realise more fully the work of modern local government. We will select the headquarters of a borough of average importance, without any of the duties relative to county administration which occupy so many of the leading towns.

The Municipal Hive. As we traverse the various departments of the hive of municipal industry, the impression is one of bewilderment at the diverse activities of its workers. The town clerk and his special staff are busy, for several committees of the council are sitting, and each involves, not merely the attendance of a committee clerk to report proceedings, but much subsequent clerical work in carrying out the committee's directions. As from eight to a dozen such meetings are held in every week of the year, complex questions involving serious interests coming before them all, it may be guessed that the amount of detailed business necessitated is enormous.

In the surveyors' department, one of its professional heads is occupied, with a large staff of assistants and draughtsmen, in considering applications and plans for laying out or draining new roads, and contractors' tenders and accounts for road repairs; or in preparing drawings, specifications and estimates of various kinds required in connection with the upkeep of highways. Another chief surveyor is engaged in conference with the municipal solicitor over some knotty point of combined drainage or the charges for a new street. Meantime the outdoor officers, in various quarters of the town, are inspecting sewage works or the watering and scavenging of the roads.

The rating branch, with its staff of collectors and clerks and its multifarious duties of scheduling property, framing assessments, and collecting the borough rate, need not detain us long. Nor shall we linger among the books of the treasurer and the accountancy officials.

Officers of Public Health. More interesting, as well as more important, is the work of the officers of the Public Health, under the control of the Medical Officer. That officer himself we may find examining diseased meat or unsound fruit seized in the market by his vigilant inspectors. More probably he is making the round of his district—here pausing to watch the tell-tale test of the smoke rocket applied to a faulty drain, there visiting a bake-house reported to be insanitary, or elsewhere investigating a case of infectious disease. His force of sanitary inspectors is busy hunting down dirt and contagion as police officers hunt down crime. One of them is supervising, perhaps, the removal of a scarlet fever patient to an isolation ward and the disinfection of the sick-room; another is in the factory quarter, on the look out for smoky chimneys, or paying a surprise visit to a "sweating" tailor, whose workshop is overcrowded and badly ventilated. A third is preparing his report to the Health Committee against the obdurate owner of an insanitary laundry, where the water lies in pools on the uneven flooring and soaks the feet of ill-shod workers. Against these and a hundred such evils—damp walls and leaky roofs, faulty cisterns and contaminated water supplies, against underground dwellings, noxious trades and every other form of nuisance—the little band of sanitary inspectors wages unremitting warfare for the common weal.

A Complex Service. Near at hand is the laboratory of the Public Analyst—a Civil Servant like the rest. Here come the suspected samples of food or medicine, to be shredded, heated, stained, evaporated, and tested in every way known to science, for signs of adulteration. The procuring of these specimens is the mission of a special officer of the borough, and many are the wiles he must adopt to be successful. If the samples prove impure a prosecution follows.

Should the borough possess its own gas works, these will employ another staff under a skilled engineer. But if it has a progressive council, abreast of the times, it will boast of municipal electricity instead. At the generating station and workshops we find a number of technical experts, from the trained electrical engineers-in-charge to the mechanics who repair street wires and lamps. The current may be employed also for electric traction, many of the provincial boroughs owning electric tramways, which are run for low fares at a handsome profit. In that case the municipal corps will be augmented by a company or so of tram drivers and conductors, regulators, and roadmen.

The list is far from being exhausted, but we need pursue our quest no further. Without lingering over such minor outposts as the public libraries, baths, and washhouses, or at that valuable device, the dust destructor, we may conclude our survey at this point. To form any idea of the extent of the Municipal Service as a whole, however, we must include, in addition to the activities of boroughs and lesser authorities, the important duties already mentioned as vested in the county councils, and the administration of the Poor Law. All these are embraced in our definition of the Municipal Civil Service.

How Appointments are made. It is not too much to say that within this varied, complex and far-reaching system almost every career can be pursued at least as effectively as for private ends. The scope afforded is generally greater, while the added distinction and usefulness of public work admit of no denial, and must appeal to all who recognise that civic patriotism is not less a virtue and a duty because it goes clad in colours less conspicuous than khaki and scarlet.

No uniform practice exists for filling vacancies in the Service. Subject, in certain instances, to the Local Government Board's approval of the selected candidate, the authority concerned is free to adopt what method it deems best. Substantially, however, the mode employed is one of three. Either the appointment is advertised and applications invited, or an existing member of the staff is promoted, or the vacancy is filled from outside on the recommendation of the responsible official in whose department it occurs.

Of the three methods the first, which is based on the sound democratic principle of "a fair field and no favour," is coming more and more into vogue for responsible positions, and for junior appointments which cannot be filled by promotion. It is certainly best, not only for candidates, but for the Service itself, that posts should be filled by honourable competition, and not by backstairs influence. Where this method is adopted, the practice is to advertise, naming the salary offered and inviting competitors to state their qualifications and experience and to forward testimonials—usually three or four. From the applications received, a committee selects probably half a dozen of the most promising, and these candidates are invited to attend in person before the council itself. The final choice is then made from among them, by vote if necessary.

The Reward of Merit. The second method, of promoting a member of the existing staff, is widely adopted for filling posts of average or minor grade. It constitutes an attractive feature of municipal employment, and by assuring merit of its reward is a powerful stimulus to efficiency. But when a specially qualified official is needed, or the responsible head of a department, it is found that, as a rule, better results are obtained by selecting candidates from a less restricted field. From the point of view of able, energetic young officers, bent on making a career for themselves, the last-named mode has this great advantage, that it saves them often from the tedious fate of finding their road to advancement blocked by some immovable "fixture" in the senior rank. There is no need to enlarge on the last of these three specified ways of filling vacancies, as it is usually adopted only when the appointment to be made is not attractive enough to create competition.

Candidates must mainly rely on entering the Municipal Service by the first gate. Once in it, they may win their spurs either in the same fashion or by promotion.

To be continued

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F. L. RAWSON, Associate Member of the Institution of Mechanical Engineers

J. W. WAINWRIGHT, Associate Member of the Institution of Civil Engineers

MECHANICAL ENGINEERING AS A PROFESSION

By Joseph G. Horner

TO become an engineer means a good deal of hard preliminary work. Its exacting character is due to the fact that the work is of a twofold character, and that it is extremely comprehensive. It is both physical and mental, involving long hours of exhausting labour in the factory, followed by study at night. There is no royal road in this pursuit, and there is no shirking hard facts. An engineer stands no chance of success unless he has a sound mind in a sound body, and the love of work. This will be sufficiently clear after we have outlined the course which has to be pursued.

The Scope of Engineering. The man who practises one of the various crafts which are included in the group of trades comprehended in mechanical engineering, is not, if his knowledge is bounded by that craft alone, an engineer. He is a pattern-maker, or a boiler-maker, or a turner, or fitter, etc. The craftsman on whom devolves the task of the final erection and completion of an engine, or piece of mechanism ready for operation, is in some sense entitled to be regarded as such, but that is not nearly all which is included in the term engineering. For, unless a man understands intelligently the practice of *all* the departments which are comprised in an engineers' works, with the scientific basis that underlies them all, and the economies of manufacturing production, he is not an engineer in the fullest sense, and is not qualified to become a manager or leader of a great works, or a designer of mechanisms. How much and what varied knowledge is involved in the principles and practice of the several trades will be seen as we progress. For the present let us take a general survey of the method by which the profession is entered.

With comparatively few exceptions, pupilage is the gateway into the broad field of engineering. The exceptions are those in which a workman by force of character and skill has broken away from his narrow trade, and qualified himself for a higher and broader sphere of action. It is with a view to lend a helping hand to men of this class who desire to "break their birth's invidious bar" that the SELF-EDUCATOR has been projected.

The First Thing to Do. If a youth intends to follow the profession of a mechanical engineer, his first course is to seek a firm with which to be articled. Some would prefer the easier, more gentlemanly, technical school. But this is a mistaken view. The school in its place, by all means; but the factory comes first. Those who advocate taking the school first point out the advantages of receiving a grounding in the principles of mechanics before going into the shops. But the elements of the sciences will already have been gathered at school and college, and it is best to enter on the field of practical work at an early date, and study theoretical science consecutively therewith.

If the decision is made to take the shops first, the choice of a firm is difficult. Many matters have to be considered. Avoid firms that advertise for pupils. The good firms always

have the names of youths on their books, who have to wait their turn for admission, in some cases for two or three years.

The selection may often have to be determined by the special branch of engineering which it is the intention to pursue in after life. This applies to those who know beforehand that they must be specialists in certain lines, as, say, in loco work, marine work, hydraulic machinery, machine tools, etc., though in any case there is much to be said in favour of some general training as a broad basis on which to rear the specialised work.

Articled Pupils. Engineering firms take pupils for terms of years ranging usually from three to five, and charge premiums from £50 to £100 a year. Occasionally, though seldom, a small wage is paid to the pupils. In return for this premium few firms undertake to impart any precise instructions. It is sufficient that lads have permission to enter and pass through the several shops, taking a part in the work that is carried on therein, and observing and noting as much as they are capable of assimilating. Excepting that they must be amenable to discipline, and to the general rules and regulations of the works, they are at liberty to occupy their time in all the shops, to put questions, make sketches and notes, handle tools, observe tests, work strenuously, or be as idle as they choose. The opportunity is there; it rests with themselves whether they shall gather golden grain, or neglect and lose the great opportunities afforded.

When a youth goes into the factory, certain lengths of time are generally apportioned to be passed in the different departments, a few months in one, a year in another, and so on, these arrangements being matters for individual settlement with the firm. The drawing office, pattern shop, and machine and erecting shops generally absorb the largest periods of time. Often some of the shops are omitted from the course, especially the foundry and smithy, occasional visits only being made to those. The period of pupilage is not long when divided up thus.

The Pupil in the Shops. Youths when in the shops are expected to dress in overalls and work like the trade apprentices and men, and to be subjected to the authority of the foremen. They undertake simple pieces of work, and often acquire considerable dexterity in the practice of the trades. But this alone is not the ultimate object of their labours, which should be to understand well what is involved in the practice of *all* the shops, rather than to become a skilful craftsman in any. Such knowledge is essential to the skilful conduct of a factory; mere handicraft is not. In this respect the training of the pupil differs from that of the apprentice to a single trade.

The work of the pupil in the shops is only one section of that which he has to undertake. He must study constantly as well. Study and work cannot be dissociated. Neither may study be allowed to become a barren field; it must be utilitarian, having a direct bearing on daily practice.

School *versus* Shop Training. Here the vexed question of technical school *versus* shop training arises. It is a pity that so much barren discussion should have arisen round this. No man can become a safe mechanical engineer unless he has had a preponderating experience in the shops. He must be a shop man first and foremost, and his technical training must be subsidiary thereto—an aid, but not in any degree a substitute. Most engineers would be better for more theoretical training, but the difficulty and danger lies in exaggerating its importance. How to strike the happy mean is not easy. We hold that the sandwich system—periods of shop work and study alternating—produces the best engineers, men who are neither too wedded to theory on the one hand, nor to rule of thumb practice on the other. Summer in the shops and winter in the colleges seems the ideal system. Or the day in the shops, and the evenings of winter in the schools—only that this makes great demands on the student's strength, and affords too little time for extensive study.

In the college one is apt to develop a "set" in favour of theory, and very much is learned which has to be modified when brought later to the test of practice. All the great engineers, living and dead, have been practical men first, and students afterwards. One's early practical training ever afterwards prevents the too great leaning on theory, and the waste of time, which is money in the shops, spent in arriving at results which practical men reach by short but safe cuts. The writer has strong views on this matter.

The Best Thing to Do. In reference to the selection of a shop being controlled by the special branch of engineering practice which it is intended to pursue in after life, there is some basis for this idea, but not so much as many might think. The very best early training for most men is to be found in a shop which deals more in general engineering and in repairs than in any single speciality. Special knowledge can be readily gathered after having been well grounded in general practice. To be brought up in a groove is not conducive to subsequent expansion and development. The fathers of engineering laid the foundations of their knowledge on a broad basis. Unfortunately for the pupil, the general shops are becoming scarce, because the manufacture of specialities pays better, but there are many firms still in which one can gain acquaintance with a varied and extensive practice. The alternative is to divide a few years among different firms. It is, however, possible that in certain cases it may be judicious to enter a special shop. For example, if a pupil has such influence in certain quarters that it is settled he is to pursue one branch of engineering only, perhaps conduct or hold a responsible position in a certain business, then it may be well to receive a training in a firm doing the same kind of work in another locality.

Engineering Departments and Allied Subjects. The prospects of the profession are not too alluring; unless a man's heart is in his work he may do better as a retail tradesman. Unless he has either capital or influence, long years of hard work must be the price of an ultimate moderate competency. But the work is good, and health and joy in one's pursuit are to be preferred to wealth alone. But there are prizes in the profession, and they come in many forms - in the form of a share in the business, as principal, or partner; the management of large works; consultative work, if a man has a speciality; posts under governments and on railways; agencies in growing countries; and professorships.

The main departments into which mechanical engineering is divided are:

AUTOMOBILES	MACHINERY AND TOOLS
BEARINGS AND SHAFTING	MINING PLANT
BOILERS	PULLEYS, GEARS
BRIDGES, DREDGERS	PUMPS, TURBINES
CONVEYING DEVICES	TRANSPORTING DEVICES
CRANES, HAMMERS	WATER WHEELS
ENGINES, FURNACES	WELL BORING PLANT
HYDRAULIC MACHINES	WINDMILLS

The scientific subjects of which a mechanical engineer should have a working knowledge embrace:

ALGEBRA	MATERIALS
APPLIED MECHANICS	MENSURATION
CHEMISTRY	MINERALOGY
ELECTRICITY	MINING
EUCLID	PHYSICS
FUELS AND HEAT	PLANE TRIGONOMETRY
GEOMETRY	PNEUMATICS
LIGHT AND SOUND	POWER OF ALL KINDS
MAGNETISM	STEAM AND WATER

APPLIED MECHANICS

The study of pure mechanical physics alone is an insufficient equipment for the designer of actual mechanisms and machines. Mathematics are faultless in the realms of pure theory, but apply them without modification to the stability of structures and the movements of machines, and they become misleading. Theory is good, inasmuch as it enables the student to think out first principles, but it must be supplemented by the corrective experiences derived from practice.

We therefore find that the whole history of mechanical practice is one of experimenting, recording, and collecting, with a view to the establishment of safe rules for guidance. The experimentalist adopts the Baconian method of reasoning from facts. He does not despise theory, he simply refuses to take it as an absolute guide. In fact, he often adopts some working theory to start with. With hardly an exception, the successful motors and machines of the present are evolutions, and not creations. Little by little they have been developed through countless imperfections and failures. The papers of the technical societies are nearly all records of experiment and experience. The so-called empirical formulæ embody the same, inasmuch as the "constant," or the "coefficient"—the central factor—is a mean derived from myriads of cases in practice. The value of hundreds of formulæ lies in this little quantity. No engineer would dare to apportion thicknesses or stresses by mathematical theories alone; he must go into the shops and learn how these have to be modified in countless ways in order to ensure security and permanence of form and action under manufacturing and working conditions.

We must grasp these facts in order to understand the full significance of the terms *applied mechanics* or *practical mechanics*. The subject is co-extensive with the design and construction of all mechanisms, machines, and structures. It is the application of the principles of mechanical physics; and machine design is but one of its principal branches. It goes much farther than this, for it includes the stability of structures that are not machines, and it also embraces the problems dealing with the pressures and movements of liquids and fluids.

The Scope of this Series. Such being its comprehensiveness, our aim will be to deal in this series with matters that are not included in, or are touched on but lightly in, the courses devoted to PHYSICS and to MACHINE DESIGN. Even then the ground left to be covered is very extensive.

It is unnecessary to enter here into definitions of energy, force, mechanical units, mass, velocity, Newton's laws of motion, friction, conservation of energy, and so on. These are explained in a lucid manner in the course on PHYSICS, to which frequent reference should be made. The attempt will be made rather to approach this subject from a standpoint slightly different from that usually taken in text books. We think that the really valuable working applications of the principles laid down and illustrated by the bare diagrams common in text books are not made sufficiently apparent. The result is that the student, who cannot be expected to possess any familiarity with actual mechanisms and machines, is thus compelled to travel over a barren field devoid of real interest. But if now we endeavour to show as far as space will permit some of the actual mechanisms in which the principles sketched in the diagrams are embodied, the study will assume a greater interest.

Statics and Dynamics. Writers on these branches have treated them as though they were two distinct subjects, but the modern way is to regard matter, whether at rest or in motion, as alike subject to the action of forces, only that in the first they are in equilibrium, producing a condition of rest, and in the second they are not so.

Disguised Mechanisms. We desire to approach this general or broad subject of applied mechanisms from the point of view of leading principles of the simplest possible character, because without such knowledge there are many mechanisms which offer very great difficulties alike to the student and to the man who works among them. The real character of many of

these is disguised by their close resemblance to others which belong to a different category. Toothed wheels, connecting rods, various constructions in which leverage is the principle without being very apparent, epic cl c trains, etc., will be instanced in due course as affording examples of this kind.

Fundamental Facts. We start with the four facts of matter, force, equilibrium, and motion. All matter is subject to the action of forces. When these are balanced we say the body is at rest, or in equilibrium, which is the same as saying that the forces to which it is subject are mutually self destructive, or balanced. Yet the stresses—the technical way of denoting the action of various forces—may be of a most intense character in a body at rest. A bridge is at rest or in stable equilibrium, yet every one of its members is subject to forces which pull, or thrust, or bend. If either member should yield to its stresses then equilibrium would be disturbed, and the static would be changed to a kinetic condition. So the stresses in a jib crane result in equilibrium, and as long as no portion yields the crane gives no sign of the forces which pull and thrust its members so severely.

The measure of a movement effected by a force is the equivalent of work done. This is represented by a definite area, enclosed either by a rectangle or by two sides of a rectangle and a third line, or curve, which varies in form with the variations in the character of the force. This is the principle not only of the indicator diagram, but of all diagrams in which work is represented graphically, or by plotted lines as distinguished from mathematical methods. Here the great value of squared paper is apparent, on which lines can be plotted in equal divisions. Vertical lines (or ordinates) generally represent forces or pressures; and horizontal ones (or abscissae) movements or displacements. Uniformly operating forces produce diagonal lines; varying and increasing forces, curved lines gradually rising from the horizontal towards the vertical.

Materials. Again, the student of applied mechanics may not, like the pure physicist and the mathematician, sublimely ignore the working aspects of things. He can only deal with line diagrams in bare calculations. But in the embodiment of such things in practice he has to handle real materials, with all the uncertainties that are inseparable from their behaviour, and this again involves questions of different kinds of stress, and their effects in strain. The strength of materials becomes of high importance, because the forces acting upon a mechanism would destroy it, either by distortion or fracture, if the strength were not carefully made to correspond with the particular stress imposed. It is therefore necessary to know first the nature, direction, and the intensity of the forces acting upon every element in a mechanism; and then the capability of a given material has to be determined to resist those forces, without distortion, fracture, or even fatigue.

Factor of Safety. Out of this arises the determination of a suitable factor of safety, which is an empirical factor deduced from diverse practice, or experiment. This looms large in design, for without it a slight extra duty imposed on a machine, or some incalculable stress, would result in fracture. It explains why a thickness is generally increased by from three to ten times that which the mathematical calculations alone would have determined; or put in another way, why a given material is only subjected, say, to one half, one fourth, or one tenth the stress obtained for it by test and calculation. This is one of the everyday differences between the deductions of pure mechanics and their application.

Rigidity. Though we speak of materials in mechanisms as rigid, the student must learn to modify that idea, since no material possesses absolute rigidity. All have the property of elasticity in greater or less degree, and this has a very important bearing on the problems of permanence of form, and alterations in strength under repeated applications of stress. Under some conditions of loading, a structure suffers more than under others. What is termed *fatigue* is a diminution of strength due to repeated applications of loads—live loads and alternating stresses chiefly. Disaster would inevitably result if a mechanism designed to carry dead loads only were subjected systematically to the imposition of live and alternating loads. The elasticity of bodies is turned to practical account in springs. These are an obvious exception to the general rule that rigidity is essential to the operation of mechanisms. Many owe their essential action to the interposition of springs, either to effect certain movements, or to check and deaden the effects of impact.

The plasticity of materials has to be taken account of also. Under sufficient pressure all metals flow like viscous liquids. This explains stretch and strain, deformation of mechanisms, and the behaviour of extruded metals and alloys, the manufacture of tubes and wires, etc.

Friction. The pranks which friction plays in mechanisms can only be studied properly in the workshops. It is often an evil, but it is also as often a most valuable aid, which is pressed into service in the numerous friction clutches, in some kinds of joints, in belt driving, and much beside. Allied to this is lubrication, by which the effects of friction are greatly diminished. Further, there is another aspect of the highest practical importance, that of extent of surfaces in contact, by increasing which the effects of friction are diminished until they become almost *nil* over a given unit of area, and the working life of surfaces in contact is prolonged for indefinite periods.

Again, friction vastly modifies the duty which a mathematical calculation would credit to a piece of mechanism. The work done is not that which is put into the mechanism, but something less, often very much less, and the ratio between the two is the "modulus" of the

mechanism. There is, further, the great fundamental distinction between the sliding and the rolling kind of friction, the latter being practically a frictionless device. Friction is a powerful modifying influence in the mechanics of water in motion, and account has to be taken of it in determining the diameters and the lengths of pipes, and the radii of bends, and the character of interior surfaces. It occurs also in the passage of air through pipes.

Kinematics. An important point to note now is that the study of applied mechanics has assumed a new interest and a different aspect in consequence of the work of Professor Reuleaux, who approached the subject from the point of view of the kinematics of machinery, or the relative motions of different parts. The old sharp divisions between the "mechanical powers" or the "simple machines" are no longer held to be sufficiently precise and accurate, since they are simplified by the newer and more rational treatment. In pursuance of this method, we will now consider what is involved in an elementary mechanism.

The Basic Conception of a Mechanism. The one essential feature in a machine, whether very simple or extremely complicated, is the mutual constraint of all its members, so that no single piece can receive or impart any movement without affecting the movements of all those to which it is connected. This definition obviously excludes a single element. It must contain two, or more, and here we must make a necessary distinction between a machine and a rigid framework or structure. A machine must possess capacity for movement in itself, even though that movement is constrained. Hence the fixed bed or base of a machine tool or an engine is not in itself a machine, but simply a support for the latter. A wheel or pulley rigidly forming part of its axle mounted on bearings is a machine, for though it is really one piece only, it comprises the lever, the fulcrum of which is in its bearings, and the length of arm is its radius. The bar termed a pinch bar is one piece, and not a mechanism, but lay a stone under it near one end for a fulcrum, and the two comprise a machine, or a lever of what is termed the "turning pair" type, the simplest elemental form possible. A screw is not a machine, but it is rendered so directly it is encircled by a nut.

Constrained Movements. Another essential feature is that the movements of a mechanism differ from those of a single piece. A bar must move in the direction in which force is applied to it. But connect it with one or more bars, and the movements of the entire system are controlled by their relationships. And so it is possible, knowing or arranging for the application of given forces on one portion of a system, to predicate the movements of the other portions, since they depend on the way in which the parts are mutually connected.

Yet again, in order that such constrained movements shall take place it is necessary to construct machines of rigid materials, as iron, steel, brass, etc. It is essential in order to preserve the forms unimpaired, for if these could become changed the mutual movements would be impaired. Out of this grows the necessity of proportioning strength to stress, in other words, of imparting such dimensions that the stresses and strains shall not exceed the pressures or tensions imposed by the externally acting forces.

It is, of course, always understood that when a machine is spoken of, it is something by which force or energy is transmitted into useful work, involving movement. But in the more comprehensive problems of applied mechanics work involving motion need not be assumed. A roof truss, or an arch, or a dam has no motion, yet each does work by virtue of its stability, due to the constrained relations of its various elements, and therefore the same principles are found present in each. The dynamic forces acting upon mechanisms produce motions of rotation (angular velocity) or of translation (linear velocity), and each may be uniform, accelerated, or retarded. These forces may be external, that is, imposed from without (external forces). These give rise to pressures, producing stresses. Stresses are defined, therefore, as resistances to alterations of form. If deformation occurs the body is strained. Stresses and strains occur both in static and dynamic problems. The idea of equilibrium must not be simply confined to the stable, unstable, and indifferent state of a body in balance. It must be extended to include the static condition of the body in itself, a term which denotes either that the body is stationary or moving with uniform velocity. Kinetic equilibrium signifies that a body is undergoing acceleration.

Centres. Coming now to the simple movements of bodies, we have the fact that these are referable to a centre, or point, or axis. This is obvious enough in the case of a rotating wheel. But it is convenient to assume the same thing in all motions — those of translation, as of rotation — only in the first named the centre is movable in space, and is often imagined to be situated at an infinite distance away. This is in harmony with the assumption of the mathematician that a straight line is an arc with a centre at infinite distance. It simplifies calculations and leads to no error. When a body has a movement of translation its supposed centre is then denoted an *instantaneous centre*, since its position changes instantly, a term, however, which has a wider application, to be seen presently. This assumption then covers all cases that can arise, including those in which a circle arc exists of immense radius, since the flattest arc must have a centre somewhere at a finite distance. These two movements, therefore, that of rotation and that of translation, include all movements that can exist. But these movements around a centre or axis may be complicated. Fortunately, nearly all those with which the mechanician has to deal occur in one plane, for which calculations are much simplified. When motions perpendicular

or in oblique relation to a plane surface occur, they introduce other problems. Few examples of these, however, will occur.

Instantaneous Centre. We may now explain more fully the value of the instantaneous or virtual centre mentioned just now. The difference between this and a fixed centre is that the first named changes its position constantly, while the latter is fixed. The virtual centre is explained by the relative motion of two rigidly constrained elements in a mechanism, the relative motion of which is unalterable, just as is that of the rim of a wheel moving round its axle, or a ball twirled at the end of a string held in the fingers. The relative positions of the body and its centre do not change with the rotation of the wheel or the ball in space. So, too, though the instantaneous centre of a moving body moves, it occupies a fixed relative position towards the *point path* of the moving body, or the essential points in that path, and the relative positions of the moving point and the virtual centre are determined by the distance between them, fixed rigidly by the connecting link of metal, or other material of the mechanism.

The instantaneous centre has no necessary relation to the *shape* of the point path, or path traced by the moving body. That may be straight, or a circle arc, or be of irregular shape. The essential fact is that any body moving in any path is at every successive instant moving tangentially to a line that connects its movement, rotational for an instant, with a centre of motion for that instant. And this movement, whatever the ultimate form of the point path delineated, coincides for each successive instant with that of a figure rotating round a centre.

Several results of a practical character follow. Since the point path lies at any instant tangentially to the virtual radius, all virtual radii for successive positions must pass through the virtual centre. The only case in which the virtual centre is at an infinite distance is that of two point paths moving in parallel lines.

An advantage of approaching the study of mechanics in this way is that principles are simplified. The fixed or permanent centre of a rotating wheel or axle becomes practically identical in its study with the instantaneous centre; often of course the two coincide absolutely.

Centrode. As the virtual centres change instantly in the general case of non-rotating bodies, they trace a path in their successive positions. This is termed the centrode, and the surface or locus of the virtual axis is termed the axode.

Elements. We next consider the meaning of what are termed *elements*, the name given to two pieces by which motion is so constrained as to render all other motions impossible, an absolute essential in machine design. This is done in numerous ways, but it is usual to classify all such devices under either one of two heads. First, they form either *turning*, or *sliding pairs*, the first being represented by the rotation of a shaft or pin in its journal or bearing, the second by the movement of an engine slipper-block between its guides, or of a die in a slot link; the first is a movement of revolution, the second one of translation. In both cases the movement is constrained to take place in directions only in one plane, and not at all in a direction perpendicular thereto.

A second classification is that into *lower* and *higher* pairs of elements, the first-named denoting a point contact only, the second a surface contact. The last-named is that which is almost universally employed in machinery, because of its greater durability. That of the higher pair, or surface contact, is only possible in plane motion, or movements of revolution, and of sliding.

Link-work. Mechanisms and machines are now regarded as being built up of link-work, comprising combinations of bodies and elements, termed kinematic links, and chains, and arranged as turning or sliding pairs. The distinction between a mechanism and a machine is, then, that between the elementary combinations, and the complete embodiment of these in a fixed base or standard which is a static body only, and a convenient means of support and attachment to the kinematic links and chains. Both statical and dynamical problems therefore are involved in the construction of machines and prime movers, and in this comprehensive manner we propose to regard our subject. If we pursue the subject of kinematic pairs one stage farther, we see that each element of such a pair may be combined rigidly with an element of another pair without interfering with the relative movement of either. Evidently, too, we are not limited to two such combinations, but there may be several such, and to such combinations the term *chain* is given. Out of this a large number of special cases arise, to which Reuleaux (just deceased, as these sheets are going to press) has given specific names, and a special notation, which are being crystallized in technical literature all the world over. The subject is rather too involved for treatment in a short series like the present, which must be comprised mainly of illustrations of practical mechanics simply explained, but the subject cannot be passed over without observation.

Unless we approach the study of applied mechanics on the lines indicated in the foregoing paragraphs, it is not possible to grasp the similar fundamental principles which underlie many mechanisms that have not even a superficial resemblance to each other; nor, on the other hand, is it easy to distinguish others which appear superficially to belong to the same group. The theoretical and the practical are thus found constantly overlapping, and in the practical is always included the question of cost, both of material and labour, a factor which may be neglected by the mathematician, but not by the designer of machinery, and this is often why one device is adopted in preference to another.

To be continued

MATHEMATICS

A COMPLETE COURSE OF ARITHMETIC, ALGEBRA, AND GEOMETRY

BEING

THE SCIENCE OF FIGURES, FROM ITS SIMPLEST ELEMENTS TO ITS ADVANCED STAGES

AND COMPRISING

Numeration	Subtraction	Decimals	Algebra
Notation	Multiplication	Vulgar Fractions	Euclid
Addition	Division	Compound Fractions	Projection

WITH

A FULL AND SIMPLE TREATMENT OF THE PRINCIPLES OF THE METRIC SYSTEM

TAUGHT BY

HERBERT J. ALLPORT, M.A. of Cambridge, Past Mathematical Master at Dunstable

A FIRST COURSE IN SIMPLE ARITHMETIC

By H. J. Allport

1. In any system of reckoning we must have a *unit quantity*—i.e. a quantity with which we compare the magnitudes of other quantities of the same kind. With this unit quantity or, more shortly, this *unit*—we use certain *numbers* to indicate how great any quantity is, when compared with the unit. By the number *one*, or 1, we mean a quantity which consists of a single unit. If we then place another quantity of the same sort by the side of this unit, we get a quantity which consists of *two*, or 2, units. By placing another unit quantity with these two, we get a quantity consisting of *three*, or 3 units, and so on. The next numbers are called *four, five, six, seven, eight, nine*; they are represented by the *symbols* or *figures* 4, 5, 6, 7, 8, 9.

NUMERATION

2. It is clear that we might go on in this way, letting each successive number have its own particular symbol. This, however, would be an impracticable arrangement, since we should have to remember the meanings of so many symbols. The following method is used instead:

Suppose we wish to count a given number of pebbles. We count out 9 pebbles, and 1 more. This gives us a quantity which we call *ten*.

We next count another ten, and continue until the pebbles are all arranged in groups of ten, and we have less than ten pebbles left.

Next, count out ten of these groups of ten, and put them together into one group. This group contains a quantity which we call a *hundred*. Go on forming these hundreds until the number remaining of the little groups is less than ten.

Next arrange the hundreds in groups of ten (each of the new groups will contain a quantity which we call a *thousand*) until there are less than ten of the "hundred-groups" remaining.

Proceeding in this way, we must evidently arrive at a point where the pebbles are arranged in heaps, of which there are less than ten.

The following names are given to the successive groups, after a thousand: *ten-thousand, hundred-thousand, million, ten-million, hundred-million, thousand-million, ten-thousand-million, hundred-thousand-million, billion*. A *million-billion* is called a *trillion*, and so on. We have thus arranged the number of pebbles in groups of ten, hundred, thousand, etc., by using no more than the 1, 2, 3, 4, 5, 6, 7, 8, 9. Such a system, of expressing numbers in words, is called *Numeration*. Since it is based on the figures *ten*, it is called the *Decimal System*.

3. *Ten* is called the *first power* of ten; a *hundred* the *second power* of ten, a *thousand* the *third power*, and so on.

NOTATION

4. We have seen how any number may be expressed in powers of ten, with the help of the figures 1, 2, 3, etc. We must now find some convenient way of representing this result by symbols.

Suppose our number is 4 ten thousands, 3 thousands, 5 hundreds, 8 tens, 9 units. Evidently, if we agree that the *position* of a figure shall show to which power of ten it refers, we need not write down the words "ten thousands," etc., and the above number would be written 43589. That is, we agree that the figure on the right hand shall represent units, the one to the left of it shall represent tens, the figure in the next place to the left shall represent hundreds, and so on. This is what is meant by the *local* value of a figure.

5. It frequently happens that some power of ten is missing from a number. We use the figure 0, called *nought* or *cypher*, to indicate this. For instance, in the number 5 thousands 2 hundreds, there are no tens and no units, so the number is written thus, 5200.

6. Names of the numbers between 10 and 100. The number 11 is called *eleven*, 12 is *twelve*, 13, 14, 15, are abbreviated from three-ten, etc., to thirteen, fourteen, etc.

20, or two-tens, is called *twenty*.

30, 40, 50, etc., are called *thirty, forty, fifty*, and so on.

7. In reading any number, such as 143589, we abbreviate "one hundred-thousand, four ten-thousands, three thousands, five hundreds, eighty, nine" into "one hundred and forty-three thousand, five hundred and eighty-nine."

8. The *figures* used in representing a number are called its *digits*.

ADDITION

9. Addition is the method for finding a number equal to two or more numbers taken together. The result of adding two or more numbers is called their *sum*.

The sign +, called *plus*, written between two numbers, denotes that they are to be added together.

The sign = is an abbreviation for "is equal to" or "equals."

10. The student must make himself perfectly familiar with the Addition Table, consisting of the sums of every pair of numbers less than 10. He must know, without mental effort, that $4 + 9 = 13$, otherwise he can never expect to become a rapid worker.

11. Example. Add together 1097; 48214; 34; 7916. We first add the units, $7 + 4 + 4 + 6 = 21$, *i.e.* 2 tens + 1. We *carry*—*i.e.* include—those 2 tens with the tens in the given numbers; thus $2 + 9 + 1 + 3 + 1 = 16$ tens, = 1 hundred + 6 tens. Carry this 1 hundred, and add it with hundreds, and so on. It is convenient to write down the given numbers under one another so that units come under units, tens under tens, and so on, drawing a line under the last number.

Thus:

	Say, mentally,
1097	6, 10, 14, 21; carry 2.
48214	3, 6, 7, 16, carry 1.
34	10, 12; carry 1.
7916	8, 16, 17, carry 1.
57261 *Ans.*	5

SUBTRACTION

12. Subtraction is the method for finding what number is left when a given number is taken away from a larger given number.

The result of subtracting one number from another is called their *difference*.

Plainly, the difference between two numbers is the number which must be *added* to the smaller to make it equal the greater.

The sign −, called *minus*, written between two numbers, denotes that the second is to be subtracted from the first.

13. Example. Subtract 1287 from 40529.

We have to find the number which, when added to 1287, will make 40529.

Write the smaller number under the larger, with the unit's figure under the unit's figure, etc., as in addition. Then, 2 added to 7, make 9. Put down 2. Next, 4 tens added to 8 tens make 12 tens. Put down 4, and carry 1 (*i.e.* 1 hundred). In this step we have made the eighty in the smaller number up to one *hundred* and twenty, and this one *hundred* is added to the 2 hundred in the smaller number. Hence, in the next step, we say 3 hundreds added to 2 hundreds make 5 hundreds. Put down 2. Next, 9 thousands added to 1 thousand make 10 thousands. Put down 9 and carry 1. Finally, 3 ten-thousands added to 1 ten-thousand, make 4 ten-thousands. Put down 3.

Thus:	Say, mentally,
40529	7 and 2 make 9,
1287	8 and 4 make 12, carry 1,
	3 and 2 make 5,
39242 *Ans.*	1 and 9 make 10, carry 1,
	1 and 3 make 4.

14. By using the above method for subtraction it becomes a very simple matter to subtract the sum of several given numbers from another given number (greater, of course, than that sum). The student will see the importance of making himself thoroughly familiar with this method when he gets to "long division."

Example. Subtract the sum of 1092, 20875, and 435, from 50171.

Put the figures down exactly as in addition, putting the 50171 first, and separating it by a line from the numbers below. Add the three lowest digits in each column, and make the sum up to the top line, as in Art. 13.

50171	Say, mentally,
1092	5, 10, 12, and 9 make 21, carry 2,
20875	5, 12, 21, and 6 make 27, carry 2,
435	6, 14, and 7 make 21, carry 2,
	3 and 7 make 10, carry 1,
27769 *Ans.*	3 and 2 make 5.

MULTIPLICATION

15. Multiplication is the method for finding the *sum* of a given number of repetitions of a number. Thus 12 multiplied by 5 means $12 + 12 + 12 + 12 + 12$, *i.e.* 60.

The number which is multiplied is called the *multiplicand*, and the other number is called the *multiplier*. The result is called the *product*. The *multiplier* and *multiplicand* are called *factors* of the product, and the product is called a *multiple* of either of these factors.

The sign of multiplication is ×. Thus, 12 multiplied by 5 is written 12×5, and is read "12 times 5."

16. In forming the product of two numbers, it is immaterial which number is taken for the multiplier. For instance, in the product 4×5, if we make 4 the multiplier, the result is $5 + 5 + 5 + 5$, *i.e.* 20; while, if we make 5 the multiplier, the result is $4 + 4 + 4 + 4 + 4$, *i.e.* 20, as before.

17. It is now necessary to make a *Multiplication Table*, *i.e.* a list of the results of multiplying all the numbers from 1 to 12 by every number from 1 to 12.

MULTIPLICATION TABLE.

1	2	3	4	5	6	7	8	9	10	11	12
2	4	6	8	10	12	14	16	18	20	22	24
3	6	9	12	15	18	21	24	27	30	33	36
4	8	12	16	20	24	28	32	36	40	44	48
5	10	15	20	25	30	35	40	45	50	55	60
6	12	18	24	30	36	42	48	54	60	66	72
7	14	21	28	35	42	49	56	63	70	77	84
8	16	24	32	40	48	56	64	72	80	88	96
9	18	27	36	45	54	63	72	81	90	99	108
10	20	30	40	50	60	70	80	90	100	110	120
11	22	33	44	55	66	77	88	99	110	121	132
12	24	36	48	60	72	84	96	108	120	132	144

The first column consists of the numbers 1 to 12. The second column is obtained by adding

each number to itself, and therefore represents the result of multiplying the first column by 2. The third column is obtained by adding the second to the first, and therefore gives the result of multiplying the first column by 3. The fourth column is obtained by adding the third to the first, and so on.

18. Example 1. Multiply 4507 by 6.

Here we have to find the result of repeating the number 4507 six times and adding. We first take six times the units' figure, then six times the tens' figure, then six times the hundreds, then six times the thousands, and add the results together. The process is abbreviated thus:

4507	Say, mentally,
6	six 7's, 42, carry 4,
	six 0's, 0, and 4,
27042 *Ans.*	six 5's, 30, carry 3,
	six 4's, 24, and 3, 27.

Example 2. Multiply 5287 by 578.

Here we find 500 times 5287, 70 times 5287, and 8 times 5287, and add the results.

Thus:

5287
578
*26435
*37009
42296
3055886 *Ans.*

Explanation. Place the multiplier so that its unit's figure comes under the unit's figure of the multiplicand. By exactly the same process as in Example 1, we find that 5 times 5287 = 26435. Therefore 500 times 5287 = 2643500 (since each digit now has 100 times its former value. Art. 4). Next we find 7 times 5287 = 37009, and therefore 70 times 5287 = 370090. Finally, 8 times 5287 = 42296.

* Note that it is unnecessary to affix the ciphers in the separate products, since the *position* of each digit indicates its value. Obviously we have only to *place the first figure of each product immediately under the multiplying digit.*

19. Multiplication by Factors. If the multiplier has factors, we may, instead of using the above process, multiply by one factor, then multiply this product by another factor, and so on, till we have used all the factors.

Example. Multiply 72486 by 147.

$147 = 3 \times 7 \times 7.$

Then,

72486
3
217458
7
1522206
7
10655442 *Ans.*

20. Suppose, in Art. 14, the several numbers to be subtracted are equal to one another; suppose, for instance, we have to take away 3 times 10875 from 50171.

The work is written thus:

	Say, mentally,
50171	three 5's, 15, and 6 = 21, carry 2,
10875	three 7's, 21, 23, and 4 = 27, carry 2,
3	three 8's, 24, 26, and 5 = 31, carry 3,
	three 0's, 0, 3, and 7 = 10, carry 1,
17546 *Ans.*	three 1's, 3, 4, and 1 = 5.

DIVISION

21. Division is the method for finding how many times one given number can be subtracted from another given number.

The first number is called the *divisor*, the second number is called the *dividend*, and the number of times the subtraction is done is called the *quotient*. The number which remains after the last subtraction (if any does remain) is called the *remainder*.

The sign ÷ written between two numbers denotes that the first is to be divided by the second.

Division is also denoted by writing the dividend above the divisor with a line between them.

Thus 28 ÷ 7 and $\frac{28}{7}$ each mean that 28 is to be divided by 7.

22. Division may be looked upon in two ways. Suppose we have to divide 28 marbles amongst a certain number of boys. Then (1) if we are told the number of boys we can find how many marbles each will get. (2) If we are told how many marbles each boy is to have, we can find how many boys will get a share.

23. It is plain from the definition of division that

divisor × quotient + remainder = dividend.

24. The multiplication table enables us to divide any given number by a number less than 13.

Example 1. Divide 3729 by 7.

We have to divide 3 thousands 7 hundreds 2 tens 9 units by 7. We cannot divide the 3 by 7, since 3 is less than 7. But these 3 thousands are equal to 30 hundreds, which, with the 7, make 37 hundreds; 37 hundreds ÷ 7 gives 5 hundreds for quotient, and 2 hundreds remainder. Calling these 2 hundreds 20 tens, and adding the 2 tens of the given number, we get 22 tens to divide by 7. This gives 3 tens for quotient and 1 ten remainder. The 1 ten is 10 units, which, with the 9 units of the given number, make 19 units. 19 units ÷ 7 gives 2 units quotient, and 5 units remainder.

Thus the whole quotient consists of 5 hundreds 3 tens 2 units, *i.e.* 532, and the remainder is 5.

The work is written thus:

	Say, mentally,
7)3729	seven 5's, 35, and 2, 37, carry 2,
532 quotient	seven 3's, 21, and 1, 22, carry 1,
+ 5 rem. *Ans.*	seven 2's, 14, and 5, 19.

Example 2. Divide 13,188 by 12.

Thus :

```
12 ) 13188          twelve 1's, 12, and 1, 13,
                      carry 1.
     1099 quotient  twelve 0's, 0, and 11,
     -------------    carry 11.
                    twelve 9's, 108, and 10, 118,
                      carry 10,
                    twelve 9's, 108.
```

The above process is called *Short Division*.

25. Division by 10, 100, *etc.*

Suppose we have to divide 1297 by 10. Now, 1297 = 129 tens + 7. $\therefore$ 1297 ÷ 10 = 129 quotient + 7 rem. Therefore, to divide a number by 10, we have only to cut off the unit's figure, this unit's figure becoming the remainder.

Similarly, to divide by 100, we must cut off *two* figures. Thus, 1297 ÷ 100 = 12 quotient + 97 remainder.

26. Long Division. If the divisor is greater than 12, the quotient is usually found by the process known as long division.

Example 1. Divide 39576 by 31.

It is usual to put the dividend between brackets, turned outwards, and to write the divisor in front of it.

```
31 ) 39576 ( 1276 quotient
             -------------
      85
      237
       206
        20 rem
```

Now, 31 cannot be divided into 3 ten-thousands, so there will be no ten thousands in the quotient. But 3 ten-thousands = 30 thousands, which, with the 9 thousands of the dividend, make 39 thousands. 31, divided into this, gives 1 thousand quotient. We write 1 (thousand) in the quotient, multiply the divisor by 1,000, *i.e.* multiply by 1, but begin writing under the *thousands* place of the dividend, and subtract the result from the dividend. *These two operations can be done in one process, as in Art. 20.*

The remainder is 8 (thousands). Writing the 5 (hundreds) of the dividend with the 8 (thousands) we get 85 (hundreds). 85 divided by 31 gives 2 (hundreds) for quotient. Write 2 (hundreds) in the quotient, multiply the divisor by 2, and subtract the product from 85. (Art. 20.)

The remainder is 23 (hundreds). Proceeding as before we see that 237 (tens) divided by 31 gives 7 (tens) quotient, and after multiplying the divisor by 7 and subtracting, we get 20 (tens) remainder. Bring down the 6 (units) from the dividend, making 206 (units) in all ; divide by 31, which gives 6 (units) quotient, and leaves remainder 20 (units).

The complete quotient is therefore 1276, and the remainder 20.

Note : (i.) that the remainder at any stage can never be as great a number as the divisor ;

(ii.) always, after "bringing down" a digit from the dividend, we must put a digit into the quotient. If, after bringing down a digit, we still have a number less than the divisor, we put a cipher, 0, in the quotient, and then bring down another digit from the dividend.

Example 2. Divide 67846250 by 843.

Here we do not get a number big enough to be divided by 843 until we use 4 figures of the dividend—*viz.* 6784 (ten-thousands). To help us to guess what figure is required in the quotient, consider only the 8 (hundreds) of the divisor and the 67 hundreds of the 6784 (ten-thousands). We know *eight* 8's = 64, so the figure in the quotient *may* be 8. If this gives too great a product to subtract from 6784, then we must try 7 in the quotient, and so on.

```
843 ) 67846250 ( 80481 quotient.
                 ---------------
       4062
        6905
         1610
          767 rem.
```

After getting our first remainder, 40 (ten-thousands), and bringing down the 6 from the dividend, we see that 406 (thousands) divided by 843 will give no thousands for quotient. Therefore, put 0 in the quotient, and bring down another digit from the dividend. (*See* Note ii. above.)

27. Division by Factors.—If the divisor has factors, none of them being greater than 12, we may get the required quotient by dividing first by one of the factors, then dividing this quotient by another factor, and so on, till we have used all the factors. The only difficulty of such a process not yet explained is the formation of the remainder after each division.

Example 1. Divide 12459 by 56.

Thus :

```
7 | 12459
8 |  1779 + 6 rem.                  } whole rem. =
       222 + 3 (seven's) rem.       } 3 × 7 + 6 = 27.
```

Since 56 = 7 × 8, we first divide 12459 by 7, which gives 1779 (sevens) and 6 rem. We next divide the 1779 sevens by 8. We thus form the 1779 sevens into 222 groups, which each contain 8 sevens, *i.e.* 56, and find we have 3 sevens left over. These 3 sevens and the 6 left after the first division make the total rem. 27.

Example 2. Divide 157651 by 20.

```
20 ) 15765|1
     7882 + 11 rem.
```

Use the factors 10 × 2. Divide by 10 as in Art. 25, giving 15765 and 1 rem. Divide this quotient by 2, giving 7882 and 1 rem. The total rem. is therefore 1 ten + 1, *i.e.* 11.

Example 3. Divide 82769 by 343.

$343 = 7 \times 7 \times 7.$

Hence:

$$\begin{array}{l|l} 7 & 82769 \\ 7 & \overline{11824} + 1 \\ 7 & \overline{1689} + 1 \\ & \underline{241} + 2 \end{array} \quad \left.\begin{array}{l} \\ \end{array}\right\} 1 \times 7 + 1 = 8 \left.\begin{array}{l} \\ \end{array}\right\} \begin{array}{l} 2 \times 49 + 8 \\ = 106 \text{ rem.} \end{array}$$

Form the rem. after the second division exactly as in Example 1. We now have 1689 groups of 49. Dividing these by 7 we get 241 quotient, and 2 groups of 49 rem. Therefore, we have altogether $2 \times 49 + 8 = 106$ rem.

EXAMPLES 1

1. Find the value of 27291 + 142386 + 22 + 907 + 600298, and write the answer in words.
2. The sum of two numbers is 1789402; the greater is 1002453. What is their difference?
3. What number must be added to the sum of 1234, 35926, 153, 2975, in order that the sum may be 50000?
4. In a train containing 389 passengers, 177 are first and second class, 262 are first and third. How many are there in each class?
5. Multiply (*a*) 14265 by 297; (*b*) 309804 by 8053.
6. A man bought 129 sheep at 35 shillings each, and 82 at 45 shillings each. If he sells the whole at 42 shillings each, how many shillings does he gain or lose?
7. Divide (*a*) 1512315 by 105; (*b*) 692853 by 528; (*c*) 316115141284 by 519602.
8. A man sold a number of cattle for £840 which cost him £720, thus gaining £2 on each animal. What did each animal cost him?
9. Divide 270 marbles amongst 3 boys, so that for every two the first boy gets, the second may get three, and the third may get four.
10. How many pounds of sugar at 3*d*. a pound must be given in exchange for 82 pounds of coffee at 18*d*. a pound?

DECIMALS

28. We may now extend the system of notation explained in Art. 4 so as to include quantities which are less than the unit.

If we have a quantity ten of which would make a unit, this quantity is called a *tenth*.

Similarly, a quantity ten of which make a tenth, is called a *hundredth*. Continuing in the same way, we have a *thousandth*, a *ten-thousandth*, etc.

29. Suppose we have to measure a given line. Having chosen our unit, we can find how many complete units the line contains. Let the number be 127, and suppose there is still some portion of a unit left.

We next find how many *tenths* there are in this portion. Say there are 6 tenths, and that some portion of a tenth remains. We now measure how many *hundredths* this portion of a tenth contains, say 4 hundredths.

And so on, until either there is no remainder, or we have measured the line to as great a degree of accuracy as we require.

The length of the line has now been found to be 127 units 6 tenths 4 hundredths, and, making the same convention as in Art. 4, viz. that the *position of a digit shall indicate to which power of ten it belongs*, we may omit the words "units," "tenths," etc., *provided we make it clear which is the unit's digit*. This is done by placing a point (called the *decimal point*) between the unit's digit and the tenth's digit. Thus the above number is written 127·64, and is read "one hundred and twenty-seven point six four."

The rules given for addition, subtraction, etc., also apply to decimals.

Addition in Decimals.

30. Example. 27·295 + ·0287 + 591·68 + 9·1846.

Write the numbers so that the same powers of 10 come under one another, as in Art. 11, or, what is the same thing, write the numbers so that the decimal points come under one another. Then proceed exactly as in Art. 11, adding the ten thousandths first, 6, 13, carry 1, etc.

$$\begin{array}{r} 27{\cdot}295 \\ {\cdot}0287 \\ 591{\cdot}68 \\ 9{\cdot}1846 \\ \hline 628{\cdot}1883 \end{array} \text{ Ans.}$$

Subtraction in Decimals.

31. Example. Subtract ·07205 from 21·651.

Write the first number under the second, so that the point comes under the point. Proceed as in Art. 13, remembering that we may consider there are 0's above the 0 and 5, since in 21·651 there are no ten thousandths and no hundred thousandths.

$$\begin{array}{r} 21{\cdot}651 \\ {\cdot}07205 \\ \hline 21{\cdot}57895 \end{array} \text{ Ans.}$$

Say, mentally, 5 and **5** make 10, carry 1.
10 and **0** make 10, carry 1.
3 and **8** make 11, carry 1, etc.

Multiplication in Decimals.

32. Example 1. Multiply 87·432 by 564.

Place the multiplier so that *its unit's digit comes under the right-hand digit of the multiplicand*. Then proceed as in Art. 18, Example 2, *i.e.* place the first figure of each product underneath the multiplying digit. The decimal point of the answer will then be directly under the decimal point of the multiplicand.

$$\begin{array}{r} 87{\cdot}432 \\ 564 \\ \hline 43716{\cdot}0 \\ 5245{\cdot}92 \\ 349{\cdot}728 \\ \hline 49311{\cdot}648 \end{array} \text{ Ans.}$$

Example 2. Multiply 31·56 by 5·49.

As before, place the unit's figure of the multiplier, *i.e.* the 5, under the right-hand digit of 31·56, and proceed as above.

$$\begin{array}{r} 31{\cdot}56 \\ 5{\cdot}49 \\ \hline 157{\cdot}80 \\ 12{\cdot}624 \\ 2{\cdot}8404 \\ \hline 173{\cdot}2644 \end{array} \text{ Ans.}$$

of life we call *animal* It would be well to consider both for a moment

The *difference* between the two is, perhaps, most apparent in their *food*. Vegetables can live on inorganic food and animals cannot. The vegetable can live on carbon, oxygen, hydrogen, or nitrogen, and build them up into organic compounds The animal, on the contrary, can only live on such organic compounds, and can therefore only exist on a vegetable world. The vegetable *stores* the force which the animal *spends*. A vegetable may be aptly compared to a hard working father accumulating large stores of wealth, while the animal rather resembles the spendthrift son who dissipates it Of course, vegetables do spend some of their force, and animals, on the other hand, store some of theirs

Large parts of vegetables (the layers of bark, etc) are lifeless and are subject to such slow changes as to resemble minerals; so within animal bodies many processes are performed by which force is stored and not expended, and such parts resemble vegetables in their action, so that no actual hard and fast line can be drawn

Five phenomena of life here claim attention BIRTH, GROWTH, DEVELOPMENT, DECAY, and DEATH

Birth marks the definite beginning of separate existence, and is an essential of every living thing, in that it implies that all life, without exception, is obtained by inheritance; and never since it first originated, as far as we know, has begun *de novo* Before the days of exact research, the contrary was believed to be true, and the presence of life in decaying animal and vegetable matter was supposed to prove that life could exist without previous life It is needless now to show how the progress of science proved this to be a fallacy, demonstrating that every form of lowest life did and could only spring from a parent of the same species Every effort to prove the theory of spontaneous generation has so far failed, and where adequate care is taken to exclude life from animal matter, no putrefaction takes place, and no living forms are found.

Growth is not confined to living beings, but in them it takes place in a totally different way from that in the inanimate world In a crystal, for instance, or in rock formation, growth takes place by the mechanical addition of layer after layer, the mass itself taking no part in the process; and growth continues, moreover, indefinitely In a living organism growth is the result of change and increase in every part throughout the being, and this growth, so long as it is healthy, has strict limits beyond which it cannot continue.

Development is a phenomenon which has no parallel in the inanimate world As growth is an increase in quantity, so development is an increase in quality, being the perfect adapting of means to ends, of machinery to work through continual use. Every organ of the body, including the brain, is thus developed by use, and becomes not only larger but more vigorous, and better adapted for its work.

Decay is now understood to be a constant manifestation of life. It used to be thought that life consisted in a power to resist decay, and it was only when life ceased that decay began. It is now found, not only that decay is an incessant accompaniment of life from birth, but that perhaps it is positively more active during life than afterwards. It is true that the effects of decay are not obvious during life, as, on the other side of the balance, the opposite force of repair or growth serves as a counterpoise to keep the body in "dynamic equilibrium"; but when the summit of life is passed, repair gets more and more feeble, and at last, ceasing in death, leaves the field free for the ravages of decay. Life is not, then, a power that resists decay, but, on the contrary, a force that cannot be manifested without it; every movement, every look, every thought, involving the decay and destruction of a certain amount of body tissue.

Death is a phenomenon quite peculiar, and necessarily so, to life; for it is obvious that nothing can cease to live save what has lived. But it is not so much an interruption of life as the final attainment of an end which was a necessity from the beginning, and towards which every act of life tended Exactly as every beat of an eight day clock is a step towards the final stopping of the mechanism, which is definitely arranged to take place at the end of eight days, so every movement of the body, and every day that it exists, is a step towards that end for which it was constructed, every body being made exactly like a clock, to run a definite time, although, of course, it may be stopped before—as a clock with the finger—by disease or accident No cause, however, is known why, in a body, when the machinery has become perfectly well balanced, and decay and repair are equal, it should not continue so indefinitely, seeing that it is self-repairing, instead of wasting away after a certain number of years.

The Three Signs of Human Life. The signs of life that are essential to life may be said to be three in number *breathing*, *the beating of the heart*, and *warmth* *Breathing* is an essential sign of life, and generally there is respiration *seventeen times a minute* The air food, unlike the solid and liquid food, must be incessantly taken, and there can therefore be no life without breathing.

The *beating of the heart*, again, is essential to life, generally about *seventy times a minute*. The supply of fresh food to the body cells by means of the circulation of the blood is a necessity of life. When the circulation ceases life must cease.

These two signs are concerned with the maintenance, or the vegetative side, of animal life The third is more connected with the purely animal side, or the spending of force, and is *heat*. The living body is always warm in some parts, its general average heat being that of hot water about 98½ degrees Fahrenheit. To maintain this requires considerable force, but it is essential to life. A body that is cold everywhere is dead.

These, then, are the three essential signs of life. It may be thought strange that no mention has been made of *movement* as an inherent quality of life, and particularly and obviously of animal life. The truth is that the mere fact of an animal being able to move is not more wonderful than that a steam engine can do the same, and movement is therefore not a special sign of life. Moreover, active life can exist without any movement at all, save the two which have been indicated—breathing and the beating of the heart.

Life as a Journey. Let us now look on life in another aspect—as a journey. The journey may be roughly divided into three stages, each lasting about twenty-five years.

The first stage, which is all uphill, consists of growth from one to twenty-five years of age. During this time is being built the house which has to be lived in for seventy-five or eighty years, but unlike other houses, it is occupied while being constructed.

During this time force is being stored up faster than it is being spent, despite the fact that the expenditure now is so heavy. Not only are all movements active at this time, but the size of the body is continually increased. Still, it is mainly now that those reserves of force on which the maintenance of health so largely depend are accumulated.

The great essential during this time is an abundance of suitable food. Roughly speaking, the body at birth is a quarter of its full height; at two and a half years it is one half; at ten, three quarters; while the full height is reached about twenty. This shows the necessity for an abundance of the best building materials to construct it.

The second stage in the journey lasts twenty-five to thirty years—or from twenty-five to fifty or fifty five—and should be a period of steady good health, when the condition of dynamic equilibrium or the balance of life is preserved, as is not the case in the other two stages. In the first stage repair exceeds destruction; in the last, destruction exceeds repair. In this third stage, however, the two should be balanced. So much food in proportion to the size of the body is not required now, as it no longer grows. Moderation in all things is perhaps the best motto.

The Decline of Life. The third stage is that of decline, and extends from fifty or fifty-five to seventy-five or upwards. The change from perfect health is at first most gradual, and in some may not really begin till nearly sixty years are reached. The manner of life may, of course, accelerate or retard the change, which soon becomes more marked. It may generally be described, where healthy, as a shrinking, drying, and stiffening of the tissues. Less food is required as the lamp of life burns more dimly; and to those who die what may be called natural deaths, the last change comes very gradually and gently. When we speak of "natural deaths" we mean such as are the result of the running down of the clock of life, rather than those due to the premature stopping of the works through accident or disease, so largely the offspring of carelessness or ignorance.

It is quite a part of physiology to understand that the life force in each man is a definite quantity exactly parallel to that stored in a watch spring; and each human being is constructed to "go," or to live, a certain definite time. Those who thus die from the expiration of their life force can alone be truly said to die natural deaths. Only about one in every nine so die in this country, the other eight do not live out their days.

Length of life necessarily is not, however, always an unmixed good, and should not in itself be an aim. It is well and wise, of course, to guard against what may be termed suicides of carelessness and ignorance, and it is partly for this purpose that these pages are written. But it is of infinitely greater importance that the life so guarded should be spent wisely and well, for the good of others and the glory of our Creator.

Whole Life. This brief survey of Life would be quite incomplete were it entirely confined to a description and definition of that part of it alone which is concerned with physical existence.

The old division of man's life into three parts—body, soul, and spirit—is now largely justified by physiological psychology. The mere body life consists in *existing*, the soul or animal life in *moving* and spending the life force; and the highest, or spirit—intelligent, moral, and intellectual life—is what really constitutes *living* to a man.

Let us repeat,

Body and Body Life Existing;
Soul and Animal Life Moving;
Spirit and Spirit Life Living

It is not a little startling to note in this connection the extreme accuracy of St. Paul's three-fold description of life to the Athenians: "For in Him we live (spirit life) and move (soul or animal life) and have our being (bodily life.)"

The Psychic life is partly conscious and partly unconscious. Broadly it may be said that about half the spirit and animal life is conducted within the range of consciousness and about half without, wholly or in part, while all the life connected with existence merely is regulated entirely unconsciously. The government of the body is thus conducted quite unconsciously; while that of the spirit is partly the unconscious outcome of character, instinct, and perhaps higher influences, and partly that of conscious will and purpose.

We cannot pursue this part of life further as the subject properly belongs to PSYCHOLOGY. It is mentioned here, because Life, after all, is one, and it is well to recognise its higher as well as its lower side. We can now turn definitely to study PHYSIOLOGY.

THE PLAN OF THE BODY

The individual man, as a whole, is increasingly forgotten both in physiology and in medicine, owing to the extraordinary minuteness and exactness with which each part and organ is examined and described. Specialism is rampant,

A little consideration will show the truth of the statement that the decimal point of the answer will be directly under the decimal point of the multiplicand. In Example 2, when we multiply by 5 (*i.e.* 5 units) it is clear that 5 times 6 hundredths = 30 hundredths, and therefore we put the 0 in the *hundredths* place of the multiplicand. Similarly, in the second line we are multiplying by 4 *tenths* and therefore the product is written one place further to the right than if we were multiplying by 4 *units*; *i.e.* we again put down our first figure under the multiplying digit and the decimal point of the product will again be under the point of the multiplicand.

NOTE. It is evident, from the way the product is formed, that the number of decimal places in the product will always be equal to the sum of the number of decimal places in the multiplier and the multiplicand. Thus, in Example 2, there are two places of decimals (*i.e.* two figures to the right of the point) in 31·56, and two places of decimals in 5·49, and we found 2 + 2 = 4 places in the product 173·2644.

DIVISION IN DECIMALS

33 (*a*) Division of a decimal by a whole number.

Example 1. Divide 18·2754 by 4.

4)18·2754
4·56885

As in Art. 24, we divide 4 into 18 (units) and have 4 (units) quotient and 2 units remainder. Since the 4 is the unit's figure of the quotient, we write the decimal point immediately after it. Then, the 2 units remainder and the 2 tenths of the dividend make 22 tenths to be divided by 4, and so on. Having reached the 4 (ten thousandths) of the dividend, we find 8 (ten-thousandths) quotient and 2 remainder. This remainder is 20 hundred-thousandths, which when divided by 4 gives 5 (hundred-thousandths) and no further remainder.

Example 2. Divide 18·2758 by 11.

11)18·2758
1·66143636...

Here we find the digits 3, 6 repeated indefinitely in the quotient. Decimals of this sort will be fully considered later.

Example 3. Divide 354·43 by 184.

184)354·43(1·92625 *Ans.*
1704
483
1150*
460
920
. . .

Proceeding as in Art. 26, we find the first figure of the quotient is obtained by dividing 184 into 354 units. Having now reached the decimal point in the dividend, we also put the decimal point in the answer, and go on as before.

* At this stage there is a remainder 115 hundredths. We bring down 0 from the dividend, and obtain 1150 thousandths, etc.

(*b*) Division by a decimal.

Example 4. Divide 10·6603 by 7·85.

Here 7·85 is 785 hundredths, and 10·6603 is 1066·03 hundredths; so that the required quotient is obtained by dividing 1066·03 by 785.

Therefore, to divide by a decimal, move the point as many places to the right as will make the divisor a whole number: move the point in the dividend the same number of places to the right. Then proceed as in Example 3.

Thus: 785)1066·03(1·358 *Ans.*
2810
4553
6280
. . . .

Example 5. Divide 176·4 by ·00012.

12)17640000
1470000 *Ans.*

Here, to make the divisor a whole number, we have to move the point 5 places. Therefore we also move the point 5 places to the right in the dividend, first writing enough 0's after the 176·4 to enable us to do so.

EXAMPLES 2

1. Find the value of 48·207 + 3·04862 + 1·0095 + 504·8 + 101·63 + ·925.
2. Add together 59·6425, ·018, 77, 2·475, 2·1, ·00021.
3. Subtract (*a*) 7·98624 from 14·571; (*b*) 52·005 from 729·08147.
4. Find the difference between (*a*) 11·435 and 7·2183; (*b*) 589 and ·589.
5. Multiply (*a*) 72·94 by 325; (*b*) 1·096 by 5·076; (*c*) ·2815 by ·5128.
6. Multiply (*a*) 53·8624 by 9·625; (*b*) ·8775 by 1·476.
7. Divide (*a*) 2·5463 by 125; (*b*) 381·116 by 11; (*c*) 1516·8 by 4800.
8. Divide (*a*) ·43843 by 17; (*b*) 71380·6 by 124.
9. Divide (*a*) ·43 by ·0025; (*b*) ·1864302 by 3·102; (*c*) ·01077687 by 5·49; (*d*) 50·1 by ·00835.
10. Divide (*a*) 300 by ·0025; (*b*) 95·0985875 by 34·75; (*c*) 40·7295 by ·00862.
11. How many times can 4·63 be subtracted from 364·1985, and what will be the remainder?
12. Find the dividend if the divisor, quotient and remainder be respectively 725·625, 81·2, ·34175.
13. Simplify $\frac{\cdot057}{22\cdot8} + \frac{3\cdot9}{\cdot104}$.
14. Simplify $\frac{6\cdot44}{\cdot023} + \frac{1\cdot02}{\cdot34}$.
15. Simplify $\frac{\cdot6 \times 1\cdot8 \div \cdot0012}{5\cdot7 \div \cdot019}$.
16. Simplify $\frac{4\cdot35 \times 60 \div \cdot29}{\cdot015}$.

To be continued

PHYSIOLOGY AND HEALTH

A PRACTICAL COURSE IN THE SCIENCE OF PHYSICAL LIFE

CONSTITUTING

A SIMPLIFIED GUIDE TO THE ANATOMY OF THE HUMAN BODY

ARRANGED IN THESE MAIN DIVISIONS

The Science of Life	The Circulatory System	The Nervous System
The Plan of the Body	The Respiratory System	The Senses
The Digestive System	The Locomotor System	And Their Functions

WITH A GENERAL CONSIDERATION OF

THE MAINTENANCE OF HEALTH AND THE REPAIR OF THE BODY IN ILL-HEALTH

The Five Laws of Health: Good Air, Good Food, Cleanliness, Proper Clothing, Exercise and Rest. Personal Hygiene. Influence of Environment. Ill-health in many Forms. Common Ailments and Domestic Remedies. Nurses, Doctors, and Hospitals. An Explanation of Medical Terms

AND A

BRIEF SURVEY OF STATE MEDICINE AND THE GENERAL PUBLIC HEALTH

BY

Dr. A. T. SCHOFIELD, Member of the Royal College of Surgeons, and Examiner for the National Health Society

LIFE, A CONDITION OF INCESSANT CHANGE

By Dr. Schofield

PHYSIOLOGY is the science of the functions, or the process of life. It is one of four divisions of Biology; the other two being Morphology or the forms of life, and Embryology or the development of life. Our special subject is Human Physiology, as distinguished from general animal physiology on the one hand, and vegetable physiology on the other.

The interest of the study is intense and may be compared to a visit to some great industrial centre, and the examination of all the wonderful processes by which some exquisite fabric is produced. We will take a journey together through the wonderful workshops of life and seek thoroughly to understand not only the exquisite details, but the governing forces, and, it may be, at times to discern the hidden Power that is the ultimate source of all Energy.

What is Life? What, then, is life? To this there are many answers. Let us take some of practical value. *Life is a condition of incessant change, dependent on the ceaseless operation of destruction and repair.* It is really a state of balance or dynamic equilibrium; that is, a balance dependent on the equality of the weight in each scale, the loss on one side being counterbalanced by the gain in the other.

Life, again, is a force of a special character, or rather a power which uses the common forces of Nature for a unique purpose. Consider for a moment the difference between an egg that is fertile and can produce a chicken—and thus contains vital power—and one that cannot. Both are organic compounds of a similar nature and chemically the same; both are the products of living beings. But the difference between them is immense.

For a time both eggs appear alike, and apart from the use of external force no difference can be seen. Both will go bad and decompose into inorganic solids and gases, and the living egg will have no advantage over the dead one. But let one of the common forces of nature—heat—be applied to both, and the difference between the two will be at once apparent. It will be seen in a few days that the life in the one egg is a capacity to appropriate and use this force progressively and eventually to produce a chicken; while the other has no such power. This chicken, in common with all other living beings, must continue to appropriate force in the shape of heat, light, and food, or the life ceases. When life does not exist, these forces cannot be used, and only hasten the process of decay.

A Directing Agency. Life, then, is a special purposive power—inherent in the living cell or organism—to use external force and manifest it in special phenomena; but it is not an independent physical force or energy, being, on the contrary, a directing agency, wholly dependent for its manifestations on the common forces of nature.

But the word Life, again, has two meanings. It may refer to the process of life in its maintenance, or it may refer to its manifestation in action. That part which refers more especially to the building up of force or the maintenance of life, we call *vegetable*, and that which is most concerned with the spending of it in the action

of life we call *animal*. It would be well to consider both for a moment.

The difference between the two is, perhaps, most apparent in their food. Vegetables can live on inorganic food and animals cannot. The vegetable can live on carbon, oxygen, hydrogen, or nitrogen, and build them up into organic compounds. The animal, on the contrary, can only live on such organic compounds, and can therefore only exist on a vegetable world. The vegetable *stores* the force which the animal *spends*. A vegetable may be aptly compared to a hard working father accumulating large stores of wealth, while the animal rather resembles the spendthrift son who dissipates it. Of course, vegetables do spend some of their force, and animals, on the other hand, store some of theirs.

Large parts of vegetables (the layers of bark, etc.) are lifeless and are subject to such slow changes as to resemble minerals; so within animal bodies many processes are performed by which force is stored and not expended, and such parts resemble vegetables in their action, so that no actual hard and fast line can be drawn.

Five phenomena of life here claim attention: Birth, Growth, Development, Decay, and Death.

Birth marks the definite beginning of separate existence, and is an essential of every living thing, in that it implies that all life, without exception, is obtained by inheritance; and never since it first originated, as far as we know, has begun *de novo*. Before the days of exact research, the contrary was believed to be true, and the presence of life in decaying animal and vegetable matter was supposed to prove that life could exist without previous life. It is needless now to show how the progress of science proved this to be a fallacy, demonstrating that every form of lowest life did and could only spring from a parent of the same species. Every effort to prove the theory of spontaneous generation has so far failed; and where adequate care is taken to exclude life from animal matter, no putrefaction takes place, and no living forms are found.

Growth is not confined to living beings, but in them it takes place in a totally different way from that in the inanimate world. In a crystal, for instance, or in rock formation, growth takes place by the mechanical addition of layer after layer, the mass itself taking no part in the process; and growth continues, moreover, indefinitely. In a living organism growth is the result of change and increase in every part throughout the being, and this growth, so long as it is healthy, has strict limits beyond which it cannot continue.

Development is a phenomenon which has no parallel in the inanimate world. As growth is an increase in quantity, so development is an increase in quality, being the perfect adapting of means to ends, of machinery to work through continual use. Every organ of the body, including the brain, is thus developed by use, and becomes not only larger but more vigorous, and better adapted for its work.

Decay is now understood to be a constant manifestation of life. It used to be thought that life consisted in a power to resist decay, and it was only when life ceased that decay began. It is now found, not only that decay is an incessant accompaniment of life from birth, but that perhaps it is positively more active during life than afterwards. It is true that the effects of decay are not obvious during life, as, on the other side of the balance, the opposite force of repair or growth serves as a counterpoise to keep the body in "dynamic equilibrium"; but when the summit of life is passed, repair gets more and more feeble, and at last, ceasing in death, leaves the field free for the ravages of decay. Life is not, then, a power that resists decay, but, on the contrary, a force that cannot be manifested without it; every movement, every look, every thought, involving the decay and destruction of a certain amount of body tissue.

Death is a phenomenon quite peculiar, and necessarily so, to life; for it is obvious that nothing can cease to live save what has lived. But it is not so much an interruption of life as the final attainment of an end which was a necessity from the beginning, and towards which every act of life tended. Exactly as every beat of an eight day clock is a step towards the final stopping of the mechanism, which is definitely arranged to take place at the end of eight days, so every movement of the body, and every day that it exists, is a step towards that end for which it was constructed, every body being made exactly like a clock, to run a definite time, although, of course, it may be stopped before—as a clock with the finger—by disease or accident. No cause, however, is known why, in a body, when the machinery has become perfectly well balanced, and decay and repair are equal, it should not continue so indefinitely, seeing that it is self repairing, instead of wasting away after a certain number of years.

The Three Signs of Human Life. The signs of life that are essential to life may be said to be three in number: *breathing*, *the beating of the heart*, and *warmth*. *Breathing* is an essential sign of life, and generally there is respiration *seventeen times a minute*. The air food, unlike the solid and liquid food, must be incessantly taken, and there can therefore be no life without breathing.

The *beating of the heart*, again, is essential to life, generally about *seventy times a minute*. The supply of fresh food to the body cells by means of the circulation of the blood is a necessity of life. When the circulation ceases life must cease.

These two signs are concerned with the maintenance, or the vegetative side, of animal life. The third is more connected with the purely animal side, or the spending of force, and is *heat*. The living body is always warm in some parts, its general average heat being that of hot water about 96½ degrees Fahrenheit. To maintain this requires considerable force, but it is essential to life. A body that is cold everywhere is dead.

These, then, are the three essential signs of life. It may be thought strange that no mention has been made of *movement* as an inherent quality of life, and particularly and obviously of animal life. The truth is that the mere fact of an animal being able to move is not more wonderful than that a steam engine can do the same, and movement is therefore not a special sign of life. Moreover, active life can exist without any movement at all, save the two which have been indicated—breathing and the beating of the heart.

Life as a Journey. Let us now look on life in another aspect—as a journey. The journey may be roughly divided into three stages, each lasting about twenty-five years.

The first stage, which is all uphill, consists of growth from one to twenty-five years of age. During this time is being built the house which has to be lived in for seventy-five or eighty years, but unlike other houses, it is occupied while being constructed.

During this time force is being stored up faster than it is being spent, despite the fact that the expenditure now is so heavy. Not only are all movements active at this time, but the size of the body is continually increased. Still, it is mainly now that those reserves of force on which the maintenance of health so largely depend are accumulated.

The great essential during this time is an abundance of suitable food. Roughly speaking, the body at birth is a quarter of its full height; at two and a half years it is one half; at ten, three-quarters; while the full height is reached about twenty. This shows the necessity for an abundance of the best building materials to construct it.

The second stage in the journey lasts twenty-five to thirty years—or from twenty-five to fifty or fifty-five—and should be a period of steady good health, when the condition of dynamic equilibrium or the balance of life is preserved, as is not the case in the other two stages. In the first stage repair exceeds destruction; in the last, destruction exceeds repair. In this third stage, however, the two should be balanced. So much food in proportion to the size of the body is not required now, as it no longer grows. Moderation in all things is perhaps the best motto.

The Decline of Life. The third stage is that of decline, and extends from fifty or fifty-five to seventy-five or upwards. The change from perfect health is at first most gradual, and in some may not really begin till nearly sixty years are reached. The manner of life may, of course, accelerate or retard the change, which soon becomes more marked. It may generally be described, where healthy, as a shrinking, drying, and stiffening of the tissues. Less food is required as the lamp of life burns more dimly; and to those who die what may be called natural deaths, the last change comes very gradually and gently. When we speak of "natural deaths" we mean such as are the result of the running down of the clock of life, rather than those due to the premature stopping of the works through accident or disease, so largely the offspring of carelessness or ignorance.

It is quite a part of physiology to understand that the life force in each man is a definite quantity exactly parallel to that stored in a watch spring; and each human being is constructed to "go," or to live, a certain definite time. Those who thus die from the expiration of their life force can alone be truly said to die natural deaths. Only about one in every nine so die in this country, the other eight do not live out their days.

Length of life necessarily is not, however, always an unmixed good, and should not in itself be an aim. It is well and wise, of course, to guard against what may be termed suicides of carelessness and ignorance, and it is partly for this purpose that these pages are written. But it is of infinitely greater importance that the life so guarded should be spent wisely and well, for the good of others and the glory of our Creator.

Whole Life. This brief survey of Life would be quite incomplete were it entirely confined to a description and definition of that part of it alone which is concerned with physical existence.

The old division of man's life into three parts—body, soul, and spirit—is now largely justified by physiological psychology. The mere body life consists in *existing*; the soul or animal life in *moving* and spending the life force; and the highest, or spirit—intelligent, moral, and intellectual life—is what really constitutes *living* to a man.

Let us repeat,

Body and Body Life Existing;
Soul and Animal Life Moving;
Spirit and Spirit Life Living.

It is not a little startling to note in this connection the extreme accuracy of St. Paul's three-fold description of life to the Athenians: "For in Him we live (spirit life) and move (soul or animal life) and have our being (bodily life)."

The Psychic life is partly conscious and partly unconscious. Broadly it may be said that about half the spirit and animal life is conducted within the range of consciousness and about half without, wholly or in part, while all the life connected with existence merely is regulated entirely unconsciously. The government of the body is thus conducted quite unconsciously; while that of the spirit is partly the unconscious outcome of character, instinct, and perhaps higher influences, and partly that of conscious will and purpose.

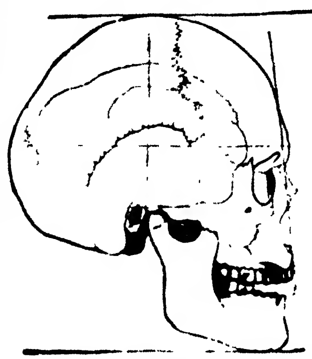
We cannot pursue this part of life further as the subject properly belongs to PSYCHOLOGY. It is mentioned here, because Life, after all, is one, and it is well to recognise its higher as well as its lower side. We can now turn definitely to study PHYSIOLOGY.

THE PLAN OF THE BODY

The individual man, as a whole, is increasingly forgotten both in physiology and in medicine, owing to the extraordinary minuteness and exactness with which each part and organ is examined and described. Specialism is rampant,

not only in medicine but in physiology; and we will therefore take particular pains, both here and in the sections of health and ill health, to keep the man as a living personality, an essential unity, always before the mind.

Remember that the body is not a mere town, full of different factories, carrying on various trades. It is an organic whole, and what makes it one is not the similarity or unity of the machines and processes, for they are unlike and many; but it is the unity of the one governing force, the mind, and especially the unconscious mind, which presides over the body. Nothing in the body is *merely* mechanical, although there is much mechanism; all is vital, all is united in one great aim—the health and well-being of the individual.



1. EUROPEAN SKULL, SHOWING FACIAL ANGLE OF 75°.

Having briefly discussed the question of what life really is, and of what its principal features consist, and having taken a survey of its various stages, let us now examine an individual man as he stands erect before us, and see what we can learn of the human body from an external view.

The Exterior. Notice, first of all, the shape of the *head*, the large proportion the brain bears to the face, greater than in any animal. Remember that the *brain* occupies the whole of the head [1] behind and above a line drawn across the eyebrows and continued to the lobes of the ears. Observe that the forehead and the face and eyes lie as nearly as possible in the same plane, and that the line from the forehead, with that from the ear to the lower edge of upper teeth, forms almost a right angle; an arrangement only suited for the erect attitude, and obviously most inconvenient if man went on all fours, when "he could see and smell nothing but the ground" (Holden). As it is, his *eyes* can command the greatest possible range of vision, their scope being only limited on the inner side by the bridge of the nose, when vision is taken up by the fellow eye. Observe the eyebrows above, keeping the "sweat of the brow" from deluging the eyes. The eyes should, for beauty, be rather deeply set, prominent eyes being never seen in ancient art. The nose, too, is not placed, as in animals, so as to scent prey in advance, which to them is of the greatest use, but so as to receive odours from below, and especially of all food going into the mouth. The *mouth*, again, to man, is of as much value for articulation in speaking as for eating, and hence the jaws are not prominent, and the cavities within are specially arranged for the reception and conduction of sound.

Now study, finally, the unique form of expression that lies in the muscles of the face. The science of physiognomy is most valuable and interesting, for undoubtedly these facile muscles get insensibly moulded by the passions and habits of the man, whose character can be far better read by the lines round his mouth than by the so-called "expression" of the eye, which really depends on the facial muscles, or the bumps on his head, often caused by thickening of the bone.

The *ear*, the great beauty of which is its small size and perfect lobe, is not able, as in animals, to turn forward or backward to catch distant sounds, man having other means of protection from his enemies and of providing his food than the faculties of scent and hearing.

Now look at the *neck*. Note the strong, bony column surrounded by muscles everywhere but in front, where you see the prominent "Adam's Apple," the front of the larynx, or voice-box.

2. THE SKELETON.

Framework of the Body. Look now at the *body* [2], and notice generally how all its complicated framework in the living man is hidden and blended so as to present but one harmonious whole. Observe that the *chest* is much broader than it is thick; an arrangement only found, among mammals, in man, and in some of the highest apes. This arrangement throws the arms much more apart than the legs, giving them a much wider range for grasping, but making them weak and useless for walking. In other animals, on the contrary, the upper part of the chest is narrow, to allow the forelegs to come close together, and stand directly under the trunk they support. Notice the bony framework of the chest, which is formed by the ribs and breastbone.

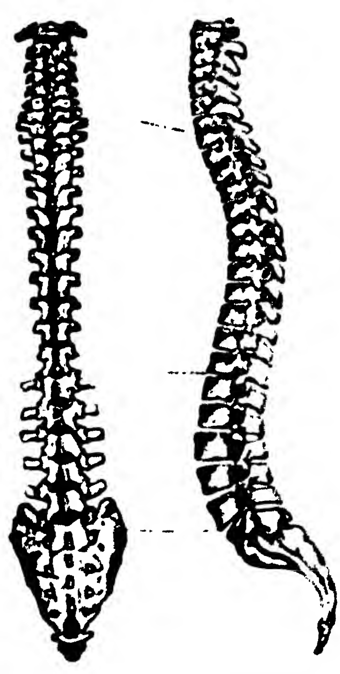
It will interest you to observe that if these were continued all the way down we could not stoop, and could hardly move. These special points just enumerated, and others, show that man is not a quadruped that has learned to stand erect. His arms are not in any sense

forelegs, for his whole body and every limb is designed for the *erect attitude* and for that alone. The lower half of the body, *the abdomen*, therefore, is protected instead by a firm but yielding wall of strong muscles, added to which are elastic fibres. In animals who walk on all-fours these fibres form a complete elastic belt to support the body. Note, moreover, that the heaving of the chest and beating of the heart are all conducted within the thorax, or chest; so that the three great organs necessary to existence—the brain inside the skull, the lungs and the heart beneath the ribs—are thus entirely protected from all ordinary injury.

3. BONES OF HAND.

Divisions of the Body. We have alluded to the bony framework, and we may note one or two facts about it now. If we divide the body into six parts—four limbs, trunk, and head and neck—we find each part contains about thirty bones (counting the ribs in pairs), there being about *two hundred* in all the body. The height of the body depends mainly on the length of the bones of the lower limbs.

Observe, now, the *arms* generally, and their position: the looseness of the shoulder joints, adapted for universal movement, but not to sustain the weight of the body. Note that the forearm does not fold on the upper arm, but to its inner side towards the mouth, a more useful position. Look at the *hand* and wrist [3], which alone contain some twenty-seven bones. The supple strength of the wrist; the value of the thumb; not placed in a line with the other fingers, but in advance of them, and so as to touch them all; the nails, arranged to support the finger-tips, and yet not to interfere with their touch, are worthy of note. The hands are marvels of precise and adapted mechanism, capable, not only of executing every variety of work, of expressing many emotions of the mind, but of executing its orders with inconceivable rapidity.



Back View. Left Side View

4. THE SPINE.

Beautiful Proportions. Take, now, a wider view of the *beauty* of the human figure. Let the person stand with feet together and outstretched arms. His breadth should now be equal to his height; and the four sides of a perfect square will in a perfect figure touch the soles of the feet, the crown of the head, and the tips of the fingers. Of the height, the hand should measure one-tenth part, the forearm one-quarter, the head one-eighth, the face one-tenth, the leg (from knee-cap to foot) one-quarter; while the greatest width of the chest should measure one-fifth, the least one sixth; the breadth of the nostrils should equal the length of the eye; the mouth should be half as long again; the forehead should be the same breadth as the nose is long. Such a figure is a perfect human structure.

Coming down the *trunk*, observe that the rugged outlines in statuary in the male figures are all due to muscular development, indicating strength; while the smoother curves of the female figures are due to the preponderance of fat. Observe, by the way, how every part is so moulded that those forms, the commonest in human designs and machines, straight lines and angles, hardly exist in the body at all. In the erect position one of the beauties of the body is its perfect balance, and the way it conforms to the laws of gravitation.

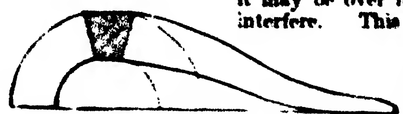
Notice, now, that the *waist* is a natural and not an artificial product, but that it forms, as we have said, not an abrupt angle, but a hollow curve from above downwards, and an *ellipse*, and not a circle, horizontally. Observe that in the male figure the shoulders are rather broader, and in the female slightly narrower than the hips, so that the male form somewhat resembles a single inverted cone, the female a double one.

Notice how broad and strong the *haunch bones* are as compared with those of animals, since the erect position requires large bony attachment for muscles to maintain it; part of the weight of the internal organs also is directly supported by the pelvis in the erect position.

Now before looking at the legs turn to the *back*, and observe the spring given to the figure by the beautiful double curve of the backbone, so admirably adapted, as we shall see in another chapter, to break shocks going to the brain. In the infant the spine is quite straight, and no animals possess the spinal curves we do, which are only required in the erect position.

The head and spine contain the centres of the nervous system; the upper part of the body or chest is the seat of the respiratory and circulatory systems; the lower part, or stomach, is the seat of the digestive and excretory systems; and the limits of the locomotor system.

Another mode of looking at the structure of the body is more anatomical. Man is a member of the vertebrata. His body has an internal skeleton, of which the chief feature is the central axis or backbone. Considering the skull and backbone as one, the body may be said to be built up of two tubes [7]. The smaller posterior or neural tube includes the cavity of the skull and the vertebral canal. Within this tube is lodged the nervous centre, or engine, of the body. The anterior, or body, tube is much larger, consisting of the face above, and the neck and trunk below, and it contains the four nutritive systems of life, so that the whole body in section is like an 8 with the lower circle immensely exaggerated [8]. The limbs, of course, are not tubular, and merely form part of the machinery. If we look again at 7, we shall see that in the first tube there is a curved division. Recalling our first simile of the human engine and boiler and machinery, we see that the limbs, etc., are the machinery, the posterior tube the engines and force that move them, and the anterior (darkly shaded) tube the human boiler that generates the force; this boiler, like one in a steam engine, has an upper and lower part. The upper part, above the curved line, is where the steam is generated (in lungs) and sent to the engine (the brain) by the heart. The lower part, below the curved line, is where the fuel is burnt (the stomach) and the ashes and refuse drop through (the intestines). So that the analogy between the two is close and striking.



6. DIAGRAM OF ARCH OF FOOT.

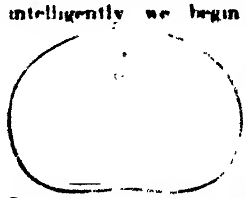
Centres of Control. Let us now consider how the various parts of the body are worked and controlled. There are two distinct seats of government in the human body: the one in the upper brain, or cortex, the other principally in the very centre of the human body. That in the upper brain, or cortex, is the human will and the conscious mind. It is absolutely autocratic, supreme, godlike, in its qualities, and responsible only to the Creator. This imperious and imperial human will has absolute control given to it over the animal part of the human life—that is, over the part that consists in the using of force, which includes the nervous and locomotor systems, and the special senses. The other government, situated in the lower part of the brain and spinal cord and in the centre of the body—in front of the spine and behind the stomach—is of an entirely different order. It is, indeed, a most complete and absolute system of "home rule." The imperial government of the brain proper has no power over any of its actions; absolute though it may be over its own domain, here it cannot interfere. This home-rule government, or "the unconscious mind," has full and undisputed sway over life itself, particularly over vegetable, as distinguished from animal, form—that is, over the generating and storing of vital force, rather than over its usage. Over the latter, indeed, it has some slight control, but only so far as to enable it to assist the former. To put this more plainly: The four systems that lie in the body—*digestive, circulatory, respiratory,* and *excretory*—may be termed the nutritive systems, being designed for the maintenance and storage of life forces. They are almost entirely under the control of the involuntary nerve centres.

7. THE TWO TUBES IN THE BODY.

Voluntary and Involuntary Acts. In physiological language, that part of the nervous system which we have referred to as the imperial government is termed *voluntary*, because it is under the control of the will. Thus, when we wish to exert force by lifting the forearm, a message is sent from the central part of the nervous system to the muscles, which contract in obedience to our desire. But such acts as breathing and the beating of the heart, over which we have very little control at all, which are controlled by what we have termed the home rule government, are, because of this lack of conscious control, termed *involuntary* acts.

From this division of government, we see that we have no power over the processes or functions of life, our sole concern being rightly to use the forces continually placed at our disposal. We do not digest our food, move the heart, or even the lungs, by any constant and direct effort of will. If, indeed, it were so, and the whole of our bodies were under our own control, the management of our bodies would so absorb the mind as to leave it no leisure to attend to external affairs at all. As we study Physiology intelligently we begin dimly to discern the Wisdom that alone has made possible human and intellectual life.

To be continued



8. SECTION OF THE TWO TUBES.

[A short glossary of terms used in Physiology is given on the following page.]

A SHORT DICTIONARY OF PHYSIOLOGY

ACETABULUM The socket in hip joint into which thigh bone head fits.
Afferent nerve A nerve which carries an impulse to the brain.
Afferent vessel Carries blood to lungs or other purifying organ.
Alimentary Pertaining to food.
Ampulla Part of the internal ear in vertebrates.
Aorta The main artery of the body.
Appendix A blind tube extending from the caecum.
Arterial Pertaining to an artery. Pure blood.
Artery A vessel carrying blood from the heart.
Articulation A joint.
Assimilation The process of converting digested food into body tissue.
Auricle A cavity in the heart.

BICEPS The muscle which bends the fore arm.
Bicusp'd The first two grinding teeth in each jaw.
Bile The secretion of the liver.
Bile-duct Tube leading from liver to intestine which carries the bile.

CAECUM A blind tube in intestines.
Calcaneum The heel bone.
Canine The eye teeth outside the incisors.
Capillaries Microscopic blood vessels having very thin walls.
Cardiac Pertaining to heart.
Carotid The main artery carrying blood to the head.
Carpal Pertaining to the wrist.
Carpus The bones of the wrist.
Cartilage Gristle, the covering of the ends of many bones.
Caval veins The large veins which carry impure blood to the heart.
Centrum The body of a vertebra.
Cephalic Pertaining to the head.
Circulatory organs The structures which convey blood and lymph.
Coagulation The process of clotting in blood.
Cochlea A bony part of internal ear.
Columnar epithelium Epithelium made of elongated cells placed at right angles to the surface.
Condyle A bony projection which helps to form a joint.
Connective tissue That which binds or connects tissues together.
Contractile — Having contracting power.
Cornea - The membrane in fore part of eye through which light passes.
Corpuscles - Microscopic cells in blood or lymph.
Cortex The outer layer of brain.
Costal Pertaining to the ribs.
Cranial nerves Nerves which arise from the brain.
Cranium - The brain case or skull.

DENTINE - The hard part of teeth.
Dermis The inner layer of skin.
Diaphragm The muscle separating the chest from the body.
Dorsal - Pertaining to the back.
Duct - A tube, generally carrying the secretion of a gland.

EFFERENT nerves - Nerves transmitting impulses from the brain.
Efferent vessels—Vessels which carry pure blood from the lungs.
Embryology - Science of development.
Epidermis - The outer protective layer of skin.
Epiglottis— An elastic structure which prevents food entering air-passages.
Epithelium—Cells which cover surfaces on or in the body.
Excretion The processes by which waste matters are expelled.
Extensor A muscle which straightens or extends a limb.

FEMORAL Pertaining to thigh.
Femur The thigh bone.
Fibula The smaller bone on the inner side of the lower leg.
Flexor A limb-bending muscle.
Foramen A hole in a bone through which a vessel or nerve passes.

GALL - Bile.
Gall-bladder The bag in which the bile is stored.
Ganglion Collection of nerve-cells.
Gastric Relating to the stomach.
Gastric juice The digestive fluid of the stomach.
Glenoid cavity Socket into which head of upper arm bone fits.
Glottis The opening into windpipe.
Grey matter The cellular part of the nervous system.

HÆMOGLOBIN The colouring matter of blood which carries oxygen.
Hepatic Pertaining to the liver.
Humerus The upper arm bone.

INSERTION The end of a muscle attached to a movable part.
Intercostal Between the ribs.
Iris The coloured part of eye.

LACTEALS Lymphatic vessels of the intestine.
Larynx The voice box.
Ligament A strong fibrous band connecting two bones.
Lymph A clear colourless fluid containing corpuscles.
Lymphatic gland A swelling on a lymphatic vessel.

MAXILLA A bone of the jaw.
Membranous labyrinth Part of internal ear.
Mesentery A membrane which holds the intestines in position.
Metabolism The chemical changes which take place in the body.
Metacarpus The bones of the palm.
Metatarsus The bones of the instep.
Mitral Valves on the left side of the heart, between auricle and ventricle.
Molar A permanent check tooth.
Mucous membrane A soft membrane lining a tube.

NERVE-CELL The essential part of a nerve unit.
Nerve-fibre The thread extending from a nerve cell.
Neural Pertaining to the nerves.
Neuron A nerve cell and its prolongations.
Nuchal Pertaining to the neck.

ŒSOPHAGUS - The gullet.
Oral - Pertaining to the mouth.
Orbit Cavity containing eyeball.
Origin The end of a muscle attached to a fixed part.
Osmosis - The process by which fluids or substances pass through a membrane.
Ossicle —A little bone.
Ovary - The female sexual organ containing eggs.
Ovum—An egg cell.

PANCREAS—The sweet-bread, a gland in the abdomen.
Papilla —A little projection.
Parotid—A gland producing saliva.
Patella—The knee-cap.
Pelvis— The bones to which the hind or lower limbs are joined.
Pepsin—A digestive ferment in gastric juice.
Peptone—A soluble substance produced in digestion.
Pericardium—The membrane in which the heart lies.
Peristaltic—The movements of the intestine.
Phagocyte—A colourless corpuscle.
Phalanges - The finger and toe bones.
Pharynx —Cavity at back of mouth.
Physiology—Science of function.
Portal— Pertaining to the vessels which carry blood to the liver.
Pulmonary - Pertaining to lungs.
Pyloric - The end of the stomach nearest the intestine.

RADIUS - The bone of the forearm on the side of the thumb.
Retina - The internal coat of eye.
Rouleaux Little rolls or chains of blood corpuscles.

SALIVARY Glands producing saliva.
Scapula The shoulder-blade.
Sclerotic - The external hard coat of the eye.
Sebaceous gland—A gland producing an oily secretion.
Segmentation The early divisions of a germ cell.
Semilunar Valves on left side of the heart between ventricle and aorta.
Sensation A state of consciousness.
Serum The colourless fluid element of the blood.
Spinal cord—The mass of nerve tissue with the spinal column.
Spleen - A large gland in the abdomen.
Stationary air - Air which remains still in the lungs in breathing.
Sternum—The breast-bone.
Sympathetic nervous system - Part of the nervous system regulating blood supply and other functions.
Synovia The fluid which lubricates the joints.
Synovial—That which secretes synovia, e.g. the synovial membranes.

TARSUS - The bones of the ankle.
Tendon The strong fibrous band which attaches a muscle to a bone.
Thoracic duct - Tube which receives lymph and opens into the great neck veins.
Thorax —The chest.
Thymus - A ductless gland near heart.
Thyroid A ductless gland in neck.
Tibia - The shin-bone.
Tidal air Air taken in at an ordinary breath.
Trachea—The windpipe.
Tricuspid - Valves on right side of heart, between auricle and ventricle.
Tympanum The drum of the ear.

ULNA - The bone of the forearm on the little-finger side.
Ureter The tube which carries urine from the kidney.

VALVE— A flap in a vessel or tube preventing backward flow of fluid.
Vein - A vessel carrying blood towards the heart.
Venous - Pertaining to a vein. Impure blood.
Ventricle - The thick-walled chambers of the heart which by contracting force blood into the arteries.
Vertebra — A bone of the backbone.
Viscera - The internal organs.
Vocal chords - Two thin folds of elastic tissue in the larynx.

WHITE matter—The nerve fibres of the nervous system.

LITERATURE. JOURNALISM. PRINTING.

A PRACTICAL SURVEY OF LITERATURE AND ITS PLACE IN LIFE

BEING

AN INTRODUCTION TO THE WORLD'S GREAT BOOKS, THEIR PURPOSE, AND THEIR WRITERS

WITH STUDIES IN

The Origin of Poetry	The Essay and Essayists	Great Books in Brief
Its Purpose and Varieties	Classics and Foreign Books	Books which must be read
The Novel & its Creators	The Great Translations	Books which may be read
Modern Fiction	Historians and Philosophers	Books that need not be read

AND COURSES IN

JOURNALISM, PRINTING, PUBLISHING, AND ALL THE ALLIED CALLINGS

BY

J. A. HAMMERTON, Literary Critic, Journalist and Author

ARTHUR MEE, Editor of the HARMSWORTH SELF-EDUCATOR; and other contributors.

THE PLACE OF LITERATURE IN ONE'S LIFE

By J. A. HAMMERTON

EVERYONE is convinced that it is necessary to take food in order to live. The proposition is so obvious that it would be sheer foolishness to call it in question. It comes within the range of demonstrable facts, such as that fire burns, that rain makes us wet. But there are other varieties of facts, quite as important to know and understand, that cannot so readily be demonstrated. Of these is the fact that some knowledge of literature is essential to the living of a well-balanced life.

One can, no doubt, adduce many instances which seem to prove the opposite, so far as either side of the question is capable of proof. The Vanderbilts, the Rothschilds, came to great things as men of no literary attainments; the founder of the first family, it is said, could neither read nor write. Alas, with all his gains he remained poor; and poor, indeed, are all who, waxing rich in worldly gear, still lack that imperishable furnishing of the mind which can be acquired only in communion with the great intellects that have made the world's literature.

The Food of the Mind. Not poor merely, but intellectually dead. For as surely as the body dies for lack of food, or grows unhealthy by improper feeding, so does the mind of man languish if mental nourishment be withheld—languish and die. We have all met persons of gross bodies whose minds were vacant places where no beautiful things were, but where there might have been good store had the impulse come, the effort been made, at the proper time, toward literary culture.

After all, it is, perhaps, not so difficult to prove that the food of the mind is as essential as the food of the body; for he who has been well nourished in the physical sense and starved mentally has but to open his mouth to advertise his condition.

It is not to be inferred from this that we deem the reading of books the be-all and end-all of mental culture. Far otherwise. The simile of feeding may still be pursued. For just as there is over development of the physical man differently, but equally, by over eating or excessive athleticism, it is no uncommon thing for a man to become so attached to mere book learning that he errs at the other extreme from the physically gross person. It would, however, involve too much discussion, though entirely apposite to our argument, to enter into the numerous considerations suggested by those other classes of one-sided people who devote themselves with passionate energy to some one pursuit which, however worthy of itself and in relation to others—novel reading, for example; playgoing, book-collecting, philately—is, when allowed to occupy a man's whole thoughts, but little better than foolishness. All alike are one-sided people—those sunk in mere animal indulgence, those immersed in book learning, those who pursue with sad, superfluous devotion some one "hobby." Mental culture, of which literature is an essential part, but only a part, produces a well-balanced, four-square life.

The "Literary" Point of View. Our purpose, then, is not to praise book-learning with any indiscriminate rhetoric; nor to exalt it unduly. There are nobler things than to be rich in the lore of the world; but, let a man be never so well endowed in all the attributes of good character, he will still be the better man by some measure of acquaintance with the treasures of literature; in fact, it is hard to know how he may acquire the more worthy traits of character without the ministry of literature, direct or indirect. A man who confesses that he has no knowledge of books tells us that the blinds are close drawn on some of the windows of his soul.

Only within comparatively modern times has a class arisen which makes literature the sum of its life; the professional literary class. In ancient times the authors were men of action—travellers, architects, statesmen. They did not begin and end in a world of books; they fought battles, they adventured in strange lands, they

governed provinces, they made laws, they reared buildings; and what they wrote was in large part derived from their contact with the life of the world in which they participated, not as authors on the quest for "copy," but as men. The same is true, in a measure, of the monks, so long the conservators of letters; they were primarily concerned with the business of living and the contemplation of a future life. The literary man of our day is in constant danger of looking at life from the literary point of view as distinct from that of human experience, and his real success is to be measured mainly by his evidence of deliberate detachment from the conditions which have made it possible for so many members of the community to become professional critics of life rather than men waging the common battle of existence.

The Purpose of Reading. Clearly, for the literary class, as such, we can have nothing to offer in this treatise. Literature is not a part of their life: it is everything to them, after religion, and perhaps, in some cases, before religion. Our concern is with those in whose lives literature has an eminent part to play: ennobling—that is, with the vast majority of our countrymen.

Although the quotation is hackneyed, Bacon's dictum on reading remains unsurpassed:

"Read not to contradict or confute, nor to believe and take for granted, nor to find talk and discourse, but to weigh and consider."

Here in two dozen words is the best advice that can be given as to the purpose of reading and its place in life. One of the greatest errors of our national system of education has been the acceptance of the idea that our public schools educate the younger generation. We read of some man that he was "educated at Manchester Grammar School"; of another, that he "completed his education at Oxford." Not even our universities educate. At best, public schools and the universities prepare us for education; render us capable of being educated. No more do they achieve; cannot; for the wisest of men is learning still when he attains to the end of all things mortal.

"To weigh and consider"—that is the true purpose of all useful reading. We have not to read for the mere storing of our minds with multitudinous facts, nor yet with sensuous fancies, which seem to be the chief results of the tremendous consumption of modern printed matter. In truth, there is no reason to complain in these days that the British public reads too little; it reads quite enough, but without discrimination. In order to "weigh and consider," it is obvious that there must be discretion. And at what age comes discretion? If we knew that, we should know all. Which brings us to a point of great importance.

Reading that does not count. Biography teems with stories of prodigies who had "read everything" at fifteen. We have met in the flesh more than one of these wonders grown old, and have formed no exalted estimate of their literary judgment. We warn our readers still under twenty years of age to avoid at all costs the suspicion of being prodigies in reading. By grace of genius a boy or girl of nineteen may be a poet, but the average healthy youth unvexed by genius is not usually at that age, and rarely earlier, capable of really intelligent reading. He may, truly, have read much and derived genuine and rational pleasure from his reading, but it will be in later life that the critical faculty will assert itself and judicial appreciation of that early reading be disengaged from the vague sensations of remembered pleasure and repulsion left by the books read before the development of the faculty of criticism. We are making no dogmatic assertion as to the incidence of that faculty; but we submit that it is seldom present before the age of twenty; and for that reason we are not with those who contend that all the reading that matters in one's life has been done from sixteen to twenty-one or thereabouts.

The Beginning of Serious Reading. The young people of sixteen who are "for ever reading something or other" are more than likely, it may be roundly asserted, to become the least intelligent of readers, the least truly cultured. Not seldom do they in later life acquire a positive distaste for books; and in any case the greater part of their juvenile reading will count for little or nothing, since it was undertaken at a time when their understanding was unequal to the occasion. Children should be permitted at most to acquire the *habit* of reading, and to that end the commonest of common boys' or girls' papers serves its purpose. But by fifteen or sixteen years of age, when the greater number of British boys and girls are following some sort of employment, they are in train for guidance, and one may reasonably presume to direct their attention to such standard works as will at once give pleasure, while steadily fostering the taste for what is good and enduring in our literature—though it were worse than foolish to expect from readers so young any would-be judicial opinions as to the qualities of the books they read. We do not picture those of tender years "weighing and considering" what they read. They have read as they have played skipping-rope or blind man's buff—for pleasure; and rightly so. But, just as in our later 'teens we put these games behind us, so we should then begin to read for a different purpose—the true purpose—the culture of the mind. With crude results at first, inevitably, yet thrilling with the now awakening knowledge that books are not merely inventions for passing the time, but the most precious of all the agencies for carrying us into a full manhood.

Models to be Avoided. The purpose of art, we are told, is "to please." But all that pleases is not art. Professor Drummond, as a boy, was in love with the red-painted inside of a toy trumpet, and wondered why God had not made the whole world red. Many a child has had the same delight and wonder. "Deadwood Dick" and "Sweeny Todd" have pleased innumerable thousands of healthy boys, but

neither is a work of literary art. The true pleasure of art is that arising from the joy of consciously appreciating the work of the artist, and realising that it has wrought in our mind to its uplifting, to our better understanding of the world in which we live, and the people around us. That is the kind of pleasure which should come when the reader has begun to understand that he is reading seriously, and not until then has literature begun to take its place in his life.

Now, if this be true—and we apprehend no great opposition to our contention—it should be clear that youth is only a time for acquiring the habit of reading, not for forming judgment or presuming to pass criticism. So we contend that the voracious readers of young years are by no means models to be pointed out, except as worthy of avoiding. We have no admiration for them, and, as they are too often neurotic examples, we leave them callously out of our account. We write for ordinary healthy-minded young men and women, who are neither book-worms nor muscular numskulls.

Bring Something to Your Book. To them we say that they must bring something to the reading of books as well as take something away. They must bring some qualities of imagination, common-sense, sympathy, in addition to the elements of school-learning, in order that what they read they may "weigh and consider," and that when they have done this they may feel they have taken another step along the unending path of knowledge and self-culture. They will have their ordinary affairs to attend to: their daily tasks in office or workshop, their studies in commerce or applied science—language, engineering, whatever their taste or circumstances may dictate—their health exercises and recreations, their love-making; since reading for literary culture must not displace any of these essentials of manhood and womanhood.

We would have none become mere book-worms any more than we would have them become mere animals, examples of bone and brawn. Yet even the humblest fitter in an engineering shop is capable of enlarging and beautifying his life by a judicious knowledge of literature. We know an engineer's labourer whose taste in books is as cultured and accurate as that of many who live by criticism, whose knowledge of our standard authors is extensive and sound, who can write with great literary charm (he has contributed to the *Cornhill* and *Longman's Magazine*), and remains withal a sturdy British workingman, living a temperate and reasonable life. He is an exception to the general rule; but what is possible to one is open to many, and though we could not with equanimity contemplate the spectacle of numerous engineers' labourers bombarding the magazines with unsolicited contributions, we should rejoice to know that in the humblest walks of life as in the highest—and the need is equal in both—the pleasures of literature were rationally present.

It is with this ideal before us that the chapters which follow are penned.

HOW TO GET THE BEST OUT OF BOOKS

One point must be established at once. No one has a right to utter an opinion on any book who has not read many books systematically. The greater number of ordinary readers are totally unqualified to say whether a book is good or bad; while to aver that they like it or dislike it—however true the assertion—is an impertinence, since they have never troubled to develop the faculty of knowing how to judge. They know what they like or dislike; yes. Man Friday disliked salted food, but that did not prove salt a bad thing. The Patagonian was wont to eat his grandmother; but somehow the Briton has never considered that a toothsome dish. Similarly are many avid patrons of the circulating libraries Patagonians and Fridays, devouring with approval the things that offend all regulated tastes, or spitting out the real salt of literature.

It seems to us that to adopt the method, so commonly favoured by writers on this subject, of seasoning our advice with "elegant extracts" from celebrated authors, so that the resultant article is in great part a mosaic of mutually destructive opinions, is to perform no real service to the student. One recalls with bewilderment the conclusions of Bacon, Gibbon, Carlyle, Ruskin, Arnold, Johnson, Emerson, and a veritable multitude of counsellors more or less authoritative; and no good purpose is served by reviewing their opinions merely because they are their opinions.

The "Personal Equation" in Advice. We have steadily to allow for the "personal equation." Emerson's opinions were, no doubt, excellent—for Emerson. So with all the rest of them. We may content ourselves with a word or two on Emerson's: "Never read any book that is not a year old. Never read any but famed books. Never read any but what you like." This advice we must try to consider from the average man's point of view; and so regarded, it is the least wise counsel that could be offered by a great and wise mind. Plainly, it is useless to the average man. "Never to read a book that is not a year old." That is its soundest part; yet how unwise it is! A truly good book *may* appear this day; why wait a year before you bring your mind into touch with this new expression of a living mind? A year, if you like, before saying with decision that the new book is literature—will endure—but that is another matter. Nor is the vogue of a new book a wholly bad thing. To read what all others are reading has at least the merit of vivifying one's interest, though sober criticism may not come till later—a year later, if you will; years later. But deliberately to refrain from opening a book until it is a year old; no. Even the ephemeral in literature is not to be utterly despised; and we are persuaded that Hazlitt's oft-quoted advice as to reading an old book whenever a new one comes out is not to be taken as undervaluing all new literature, but as wise counsel not to allow the new books to crowd out the old and tried favourites.

Likes and Dislikes. "Never read any but famed books." Dubious advice, since so much depends on what is meant by "famed." "Don Quixote" is famed; "Gargantua," "Paradise Lost," "Pendennis"; so, too, "The Sorrows of Satan," "The Eternal City"—and these latter are more than a year old. "Famed," indeed! There is hardly any book, apart from trashy fiction and watery verse, that will not yield the intelligent reader some grain of knowledge, the more to be prized if separated from the chaff without the critics' guidance. There is much that is worth the reading in books that are not, and never will be, "famed," even in poor and mediocre books. As to never reading but what you like; that, too, is unwise counsel. Johnson said that "a man ought to read just as inclination leads him; for what he reads as a task will do him little good," which is a very different line of thought from Emerson's; though at first sight they seem parallel. For, as a matter of common experience, it is not the things we like that most stimulate our thoughts, but the things we dislike. The sheer pleasure of agreeing with another's thoughts tends for the time to make our own thinking a subjective faculty, if not entirely quiescent, whereas the man or the writer whose ideas disturb our equanimity, ruffle our temper, strike us rudely, will, while in no wise pleasing us, energise our own thoughts, rasp them, maybe, to smoothness and greater usefulness. It is conflict, not acquiescence, that produces activity, mental and physical; and the authors we dislike may have as much for us, if not more, than those we like. But—and here is the subtle difference between Emerson and Johnson—our "inclination" may lead us to bear company with an author we dislike, for the tonic effect of his opposing intellect. When we are conscious of this we may conclude we are reading to some profit.

The Right Way to Read. What we have to bear in mind about the "how" of reading is that there are many ways of getting the best out of a book, and that all are right. If the individual *feels* his own particular way to be right, it is right for *him*, though it might be the worst possible way for anyone else. The essential is, that he have a way; that he do not read aimlessly; that if he presume to utter an opinion on a book, he shall have deliberately come by that opinion as the result of a process of reason and study; that it be no capricious expression of an irresponsible mind. But, withal, it is still possible to indicate some rules which, modified in individual application, may reasonably be described as helps towards a practical system of reading.

Before Reading a Book. We have already pointed out that the reader must not come empty-handed to the author. We need not remark that he should know the rudiments of grammar and composition. It is necessary that he bring some quality, if it be only a conscious ignorance of the subject of study. But more usually he takes up a book already knowing something of the matter with which it deals, of the author's reputation, characteristics, previous works. Unless he is an aimless person he has also a reason for taking up a book; must have. That reason may be wise or mistaken; enough that it is a reason, that the reader is not merely bent on passing an idle hour.

Now, it happens often that the reading of one book leads to the reading of others by finding mention of them in the work just laid down. Thus, no one reading Boswell's voluminous "Life of Johnson," but has quite a host of other books therein suggested, the reading of which will be rendered (at the beginning, at least) the more piquant from knowing what Johnson thought of them. To be personal for a moment, we remember taking up "Moll Flanders," not after the same author's "Robinson Crusoe," but as the result of interest aroused in the book by Borrow's casual reference to it in "Lavengro." This was long before we could have shadowed forth any outline of a system in our own reading. It was a natural impulse, and any system is good that is based on natural tendencies, that methodises them. To note carefully the books which are mentioned as having been favourites with a man whose life we admire and would fain emulate, and to determine on a first-hand acquaintance with these, were an excellent feature of any system which the reader might evolve for himself from these and other hints.

Preparation for Reading. There are, of course, numerous reasons for reading a book, many of which are so obvious that we would but waste our space in defining them. Local interest will count for something; he is on safe ground who familiarises himself with all the notable writers identified with his town or district. If poets are chief of them, thus the reader may be led very pleasantly and far afield in the study of poetry. And it is well to have some one branch of literature, or even one author, that attracts us more than others, though never allowing this study to weaken our interest in general reading. The innate promptings of our nature must be permitted to influence us in following these by-paths of study; they will never take us astray if we are consciously in search of good.

Gibbon had a system of "self-examination" before reading any book, whereby he took stock of his own knowledge on the subject, glancing over the work to secure a rough idea of its scope before beginning seriously to study it. Thus he would know with precision how much the author had taught him when he had finished the reading of the book. Mr. John Morley has tried this method and commends it. It is, at least, one that depends upon no personal idiosyncrasy and is open to all. But we would urge a preliminary course, which is of great value and adds immensely to the pleasure of any book, supposing the reader to be only partially informed as to its writer. And that is, to turn up in any work of reference biographical particulars of the author; to furnish one's mind with the leading facts and criticisms concerning him and his writings, but *not yet* to read a full biography. Reference

should be made to more than one source of information, so that the reader may have before his mind's eye a rough sketch of the man and a brief outline of his work, before proceeding with the serious study of the book. Not until several books by the same author (provided his fame and achievement are not confined to one) have thus been studied, should his full biography be taken up.

When Reading a Book. We must never "skip" a preface. It is unfair to the author, foolish to ourselves, to omit hearing what he has to say in his preface. Overburdened as Scott's novels seem to be with prefaces and appendices, he is wise who reads them all; his grip of the romance will be far more enduring than that of the reader—and his name is legion—who boasts of always avoiding notes and introductions. If this is so in the case of fiction, it is still more so in the case of treatises in philosophy, science, travel, belles lettres. The preface is as much a part of the book as a door is part of a house.

Having read carefully the preface or introduction—sometimes we find both, and rarely, if it be a good book, without a reason—we begin the actual reading.

We have now to decide upon the qualities to observe in the work before us. These, of course, cannot be detailed in the present chapter, as each class of book presents different elements which will be specified in due course. But working examples must be given, and we shall take them from History and Fiction.

Things to Consider. In reading a historical work we have to consider (1) the author's point of view. The more picturesque and readable a historian is the more need is there to keep a sharp look-out for bias. We are pretty likely to find evidence of this, and whenever we suspect it we must refer to some other historians on the same point in order to correct our impressions; (2) the author's knowledge of men and motives, great movements, will call for examination, nothing being taken for granted unless it be an obvious statement of uncoloured fact; (3) his "style" will demand especial attention, as it is in a historian of equal importance with accuracy, and, indeed, his manner will largely determine his accuracy; one who is excessively fond of picturesque description and epigrammatic comment—Macaulay, for instance—being always open to the suspicion of letting his manner unduly colour his matter.

In a work of fiction we look for (1) a story. This is the first essential, and we have to ask ourselves whether it appeals to us as being an ingenious invention and credible. (2) Next we consider the sequence of the story. Is it unfolded naturally, inevitably? Are the events contrived as in actual life they might be? Or are they forced to fit the ends of the author? All these questions may be answered in the negative, although the first consideration be fully admitted. (3) Are the characters such as might exist in life, and do they act for just those reasons which would influence living people? Here, while (1) and (2) might be granted, (3) might be only partially allowed. (4) The vital question of "style," which includes humour, sympathy, method, personality, must be always, in some degree, present with the reader.

"Remember." There is no lack of touchstones—and we have indicated but a few—for the testing of a book, and just by the measure of the reader's *conscious testing* will he have profit of his study.

We cannot dwell on such details as the underlining of favourite pages or the keeping of a common-place book in which all thoughts arising from the study of a work will be entered and classified. But we must take occasion to say that few men have the temperament for the latter, and it is apt to render those who have, priggish and dependent in their opinions. Underlining, marginal notes, the jotting of references on the end papers, most readers do naturally, and with good results. But to *remember* is best of all, and it is as easy to write on the tablets of the memory as in a commonplace book, while it is infinitely more useful. Impressions written down are apt to be dismissed from one's mind by the very fact that the operation is intended to ease the mind of a burden, and commonplace books seldom yield their treasures at precisely the right moment, whereas the memory can be made to do so if properly cultivated. The things we remember are vastly more important in influencing the mind than those we dismiss into notebooks.

After Reading a Book. Having dealt with the preparation for and the actual progress of reading, some words on "after reading a book" may be looked for. But there is little advice of any practical value to offer, since all will now depend on the reader. When one has mastered the art of reading, he may be left to apply that to the best of his understanding. This may be said, however, that no reading of a book is complete until the reader has carefully reviewed the whole work in his mind, turned back to passages which may have puzzled him in the earlier parts and revised his first impressions in the light of his finished reading, as the end of a book, and especially of a work of fiction, may greatly modify the opinions formed in the earlier stages of its study. A good plan, if the book we have just read happens to be the first of that author's with which we have made acquaintance, is to take up some other of his writings, nor to allow the fact of its having displeased us to make us refrain from bearing him company a second or a third time. Indeed, it should be rather an incentive to our doing so, lest we allow ourselves, on the strength of one book, to form an erroneous opinion of any writer; for there is hardly any author—and few even among the giants—who has not produced one or more books which do not show him at his best. It is doubtful if we should ever set ourselves the task of reading in succession all the works of any one author, especially if he be as voluminous as Scott or Dickens. If the sequence be broken by turning to other writers, we shall be the better able to compare their styles, and so to appreciate all more accurately.

To be continued

DRAWING AND DESIGN

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CONDUCTED BY

Professor R. ELSEY SMITH, Lecturer on Architecture at King's College, University of London
WILLIAM R. COPE, Art Master at the Polytechnic School of Art, Regent Street, London
JOSEPH G. HORNER, Practical Engineer and Author of many Standard Engineering Works
PAUL G. KONODY, Past Master of the Junior Art Workers' Guild; and other experts

THE FIRST STAGES IN ELEMENTARY DRAWING

By William R. Cope

THIS course of drawing is intended for students who wish to become either artists, sculptors, designers, architects, engineers, cabinet makers, carpenters, or craftsmen of any kind, any one, indeed, who wishes to grasp the general principles of drawing will find the course adapted for him.

In the course is included freehand from the flat and the round, the principles of object drawing, geometrical drawing (plane, solid, and as applied to design,) brushwork, memory drawing, and light and shade. It forms a basis, therefore, upon which anyone can specialise for whatever career in the industrial arts or sciences he may wish to follow.

Drawing, the Universal Language. Drawing is a means of education, of training hand and eye; it quickens the powers of perception and gives scope to the inventive faculties. It trains the eye to accuracy and the mind to observation, attention, comparison, reflection, and judgment. It is the handmaid of all industrial art and science, and should be cultivated to the highest degree. It is a universal language, and the shortest of shorthands. How often it is found that some simple sketch explains very much more easily and quickly than dozens or even hundreds of words, some idea that one person wishes to convey to another! How an illustration helps to elucidate the text of a book we all know.

The term "drawing" is sometimes more particularly applied to the expression of form by line, such as is made with a pen, pencil, or other pointed instrument. But it is most important that a beginner should realise that there is no line in nature.

Nature's objects relieve themselves to the eye as spaces or masses that are lighter or darker in tone, or of colour varying with their surroundings. Consequently all expression of natural objects by line is a conventional rendering. Thus in 1 the form or space within the conventional line is separated from the surrounding part of the page, and suggests to us a flower; while in 2 we have the form or shape of the flower given in mass, without any line. It is merely dark relieved against light, or black varying with white. This *mass* drawing is much better for realising or suggesting the form of the flower.

Spaces and Lines. Almost every beginner thinks only of the turns and twists of the line, if drawing from a printed outline copy; or only of the edges if using an object for study. He is neglecting, of course, the most important part—the shape of the *space inside* the boundary line or edge. If we change two words in a well-known proverb, we get an excellent rule for drawing in any of its branches. This rule is—*take care of the spaces and the lines will take care of themselves.* The eye, in other words, must be trained to see *form*, and not merely lines and edges. By and by, the student will need to see *tone* and *colour* as well.

Many pupils find it much more pleasant to make drawings of cottages, trees, or living creatures; and unfortunately, some attempt to paint in colour, because it is so fascinating, before they know the elementary rudiments of drawing. Such misdirected efforts can only end in disaster. The work is out of proportion, the perspective is wrong, the tones and colour are false, and the performance, in fact, is lacking in most essential points. A drawing may be very neat, but if it does not give a *true* representation of the form of the object, it is of no value. Again, a picture may be carefully shaded, or even admirably coloured, but if the drawing is wrong the representation must be always unsatisfactory.

FREEHAND DRAWING.

Freehand drawing is drawing done without mathematical instruments. The materials required for it are some cartridge paper, an HB or B pencil, a sharp knife, a piece of good india-rubber, and (if the paper is not in the form of a book or a block) a drawing-board, half imperial size (22 in. by 15 in.), with some drawing pins. When more advanced, pen and ink or brush may be used. All these are now so cheap that there is no excuse for working with bad materials, thus creating unnecessary difficulties to be overcome. Then, too, some *good* copies of leaves, flowers, fruit, animals, common objects, and conventional ornament can be easily obtained. Natural leaves, flowers, shells, stuffed birds, &c., may be used to advantage as copies.

The illustrations in this course are not necessarily to be used as copies by the student. They are too small, and are used here for explaining the method to be adopted in learning to draw. The student must get copies for himself, see that they are carefully graduated in difficulty, and *practise* as much as possible.

The pencil should be sharpened as in 3 and not as in 4, and should be held lightly and at some distance from the point [3]. All sketch and block lines should be drawn lightly and freely, and not as if the purpose were to plough through the paper. A soft, grey, freely flowing line should be cultivated early, and not a hard, wiry, wobbly line.

Training the Eye to See. It is necessary that the student should keep well in mind that he must train his eye to *see* correctly, and his hand to give true expression, as artistically as he can, to what he sees. It is of little use putting down something and rubbing it out, continuing these processes perhaps half a dozen times until the drawing appears correct. There must be a definite impression in the mind before a line is drawn, and the pupil should endeavour to aim at the ideal of drawing every line correctly the *first* time. He should remember Ruskin's advice to the young man who asked how he should learn to draw. Ruskin sat down and looked for five minutes at the object for study. Then he drew one line. After another five minutes' careful observation, he drew another line, and said to the young man: "That is my advice to you on how to learn to draw." Slow, tedious work, some will say, but *so* slow and tedious is learning to play the scales in music. Ruskin meant that the student must learn to *see* before he could hope to draw, and correct sight cannot be achieved by a superficial glance.

Study the Copy. This training of the eye must be persevered with assiduously. Through all stages, in order to render the pupil capable of judging more complex things in his advanced studies—such as the subtle changes of light and shade, and the beautiful variations of colour in nature—the student must persevere in the close attention to detail and training of his observation. His judgment will be more certain, and he will find more pleasure in his work.

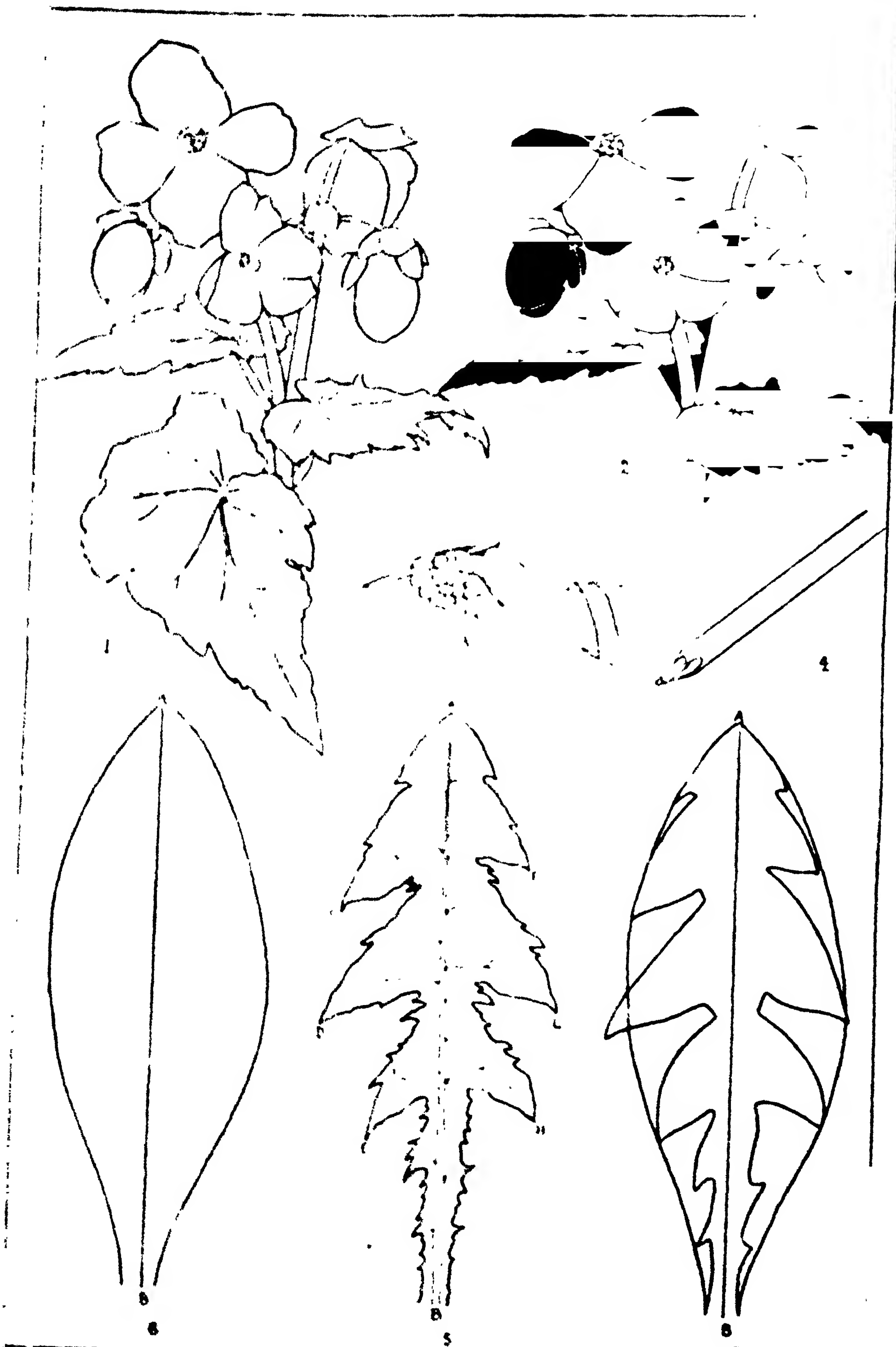
At the outset, therefore, he should carefully observe the main general proportions of the copy or object of study—how it is placed in its surroundings, its leading growth lines and masses, the peculiar growth of the plant, the pose and action of the animal. He should not trouble at first about details, but should get the main facts correctly impressed upon his mind.

Let us take now a dandelion leaf for study [5]. Let it be pinned flat on a card or board, for the sake of more readily observing it carefully and intelligently.

Some Main Points to Note. First note the general proportion between height or length, AB, and width, DG. At first glance the student will probably think the width is considerably less than half the length, but he would have been deceived by the numerous deep serrations. If a steadily curving line were drawn almost exactly through the points A, C, D, E, and another through A, F, G, H, he will see a shape as indicated in 6. It will now be observed that the width, DG, is very little less than half the length, AB. The points D and G are about equidistant from A and B; also E is equidistant from A and G, whereas C, nearer D than to A. Again, the space CF is smaller than DG. The distance GH is about one third of GB, but DE is more than one third of DB, and EH is rather less than CF. The student must endeavour to judge these proportions first with the eye alone, and then test his judgment by measuring. *On no account must he measure with a pencil or ruler first.* This would be easier and quicker, and certainly the result would be quite correct, but he must remember that he must train the eye to *see*. Judgment with the eye alone will, of course, be more or less inaccurate at first, and the work will seem slow and tedious, but this method must be persevered with if true progress is to be made. Each time the student will succeed more and more, until he will become surprised by the way in which he can *see* the true proportions.

Features to Observe. Next direct the attention to the three peculiarly shaped lobes on each side, with the deep serrations between, noticing that one of the three lobes on each side is the largest, and a subtle gradation in the size of the others. The downward direction of the characteristically shaped "teeth," from which the plant gets its name (dent de lion), the gradually thickening midrib, with its secondary branching veins, and the way in which they grow from it, should also be noted. Another important feature is the tendency of the side veins to run down towards the base of the leaf, as generally happens. These veins are also nearer the lower edge of each lobe. This thorough investigation shows what a great deal would be missed in a superficial glance, and that there is method and regularity underlying apparently irregular forms. Observe also, the decorative effect of the whole leaf.

Having now stored the mind with many facts, begin by drawing a central line AB, and the two curved lines [6]—*block* lines, they are called—rigidly keeping the relative proportion previously observed. Block in the large lobes in their true proportions, carefully noting how



THE DIFFERENCE BETWEEN LINE AND MASS, WITH A FIRST LESSON IN DRAWING.

far the main serrations go in towards the mid-rib, and leave out the smaller serrations [7]. Now put in the largest secondary veins, keeping all lines faint yet visible, so that comparison can be made between the drawing and the leaf, and discrepancies corrected. Alterations can always be made more easily and quickly at this stage, with only simple block lines to deal with, than when the details are filled in. It would be best not to sketch in details at all now, but to draw them direct in the finishing stage, when they are more likely to have the desired expression which rarely or never comes at first.

Finishing. If all appears so far correct, partially rub out block lines, and finish with a neat, fluent, and expressive line, not necessarily one that is all the same thickness. The lines for the edges might be stronger than those for the veins. There might, in fact, be varying degrees of thickness used at discretion. Do not forget in this finishing stage to very closely observe the natural leaf, in order to get true representation, and be especially careful to note the characteristic shape of teeth and serrations. The finished drawing should now be like **5** in proportion and shape of details, but the line should be more expressive and more artistic than can be rendered by a printed line. A really artistic hand-drawn line must always be more beautiful and expressive than a printed one, for there cannot well be artistic feeling in a machine.

The student should get other leaves or flowers, such as **8**, **9**, and **10**, and go through the same process of observation in every case before beginning to draw, always trying to develop his perceptive faculties.

For further explanation of the method of learning to draw we will take a copy like **11**. This is absolutely symmetrical, and is a piece of ornament founded on the honeysuckle (*anthemion*) and acanthus leaf. Observe that, although the design is conventional, there is suggested a system of growth and radiation from point B, and that the design has a sense of unity, vigour, and stability, as well as a beautiful and subtle gradation in the size of subordinate parts. Though certain forms are repeated many times, there is no suggestion of monotony. This study of the artistic side of a copy or object must be cultivated as soon as possible, not merely to add interest to the work but to increase the powers of perceiving the beautiful.

The Straight Line. On the practical side is an upper (*anthemion*) and a lower (*acanthus*) portion. The greatest width, CD, is very nearly four-fifths of the height AB, and the spaces HK, KF, FL, etc., are nearly equal. Draw first the central line AB, say, about eight or nine inches long, so as to make a good-sized drawing. It is much better not to draw on a small scale, because freedom of pencil movement should be cultivated, and a better exercise in judging proportion can be made with a drawing of moderate scale. Do not rule construction lines, but practise pure freehand drawing. When drawing the line AB be careful to keep it quite vertical, otherwise the drawing, when finished, will appear to be falling over, thus destroying the stability observed in the copy.

One of our living artists has said that not more than one person in a hundred can draw upright lines freehand. This is quite true among beginners in drawing, because, through want of thought, they do not sit properly in front of their drawing paper, or they unconsciously turn the paper cornerwise. The uprightness of the leading growth line AB ought to be judged at the start by noticing whether it is parallel to the right and left hand edges of the paper.

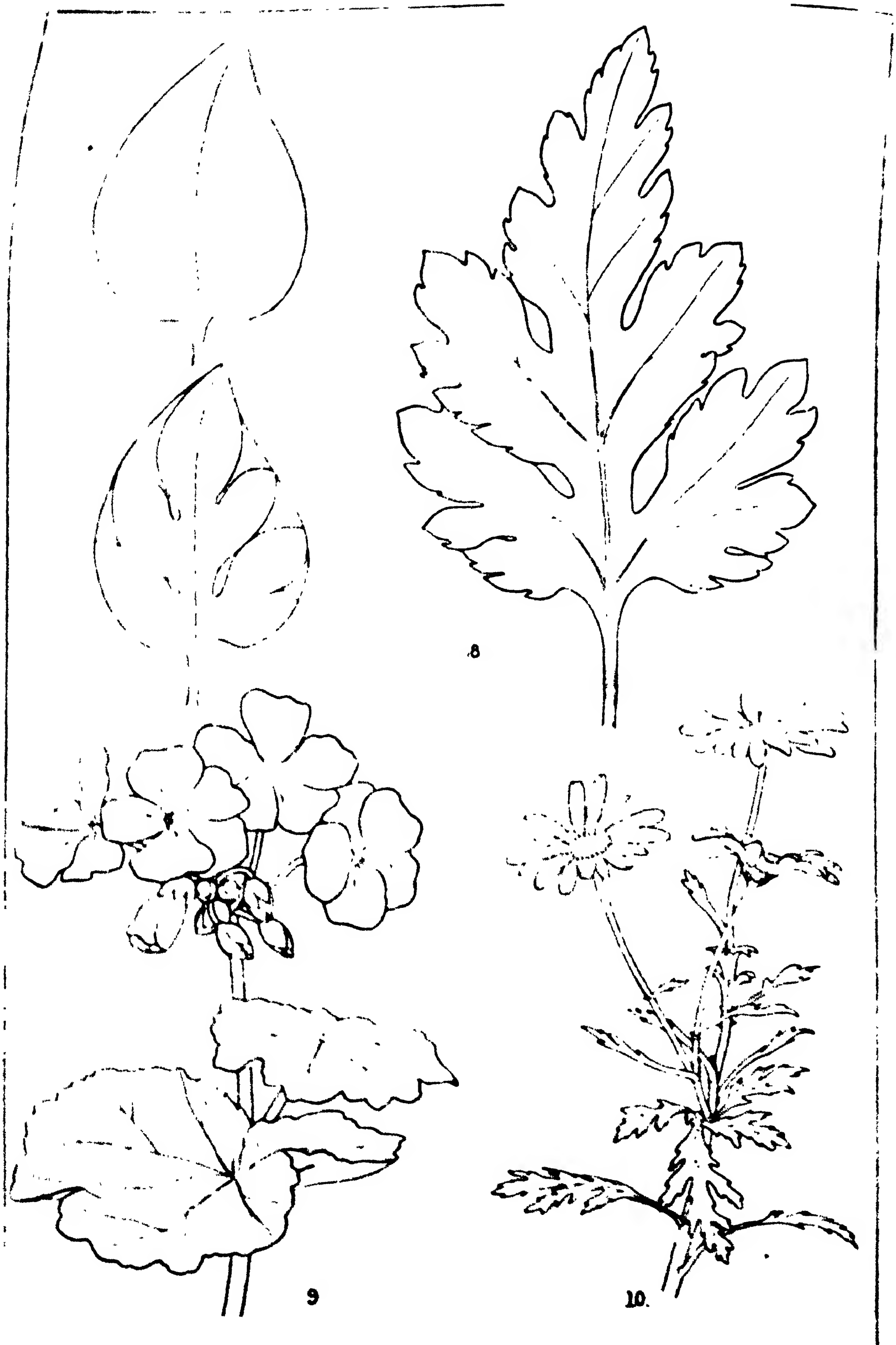
Having drawn AB correctly, do not draw a lot of horizontal lines, say, HN, KO, FG, etc., which would be getting merely mechanical accuracy and confusing the work with unnecessary lines. Determine the greatest width CD by lightly marking where the points C and D should be, being careful as to how far down they must come. Next mark the position of F and G, observing that the space FG is four-fifths of CD, and about midway between A and E. Then draw lightly and freely the block lines of the large masses indicated in **12**. Afterwards draw the leading growth lines, and the secondary block lines [**13**], observing carefully all the time the relative proportions of the spaces between them.

At this stage, again, compare the sketch with the original, and correct any mistakes. Nearly rub out the construction lines, note the peculiar shape of the serrations of the acanthus leaf, and the tangential junction of neighbouring lines of honeysuckle, and finish with a good fluent line.

The Help of Museums. The student should continue practising similar copies graduated in difficulty. He might also study from casts of ornament, or from real sculpture in relief, or from woodcarving. Many fine specimens are found in museums, churches, and any interesting old buildings. A sketch book should be carried in readiness for sketching any rare and beautiful piece of ornament, which may be useful for reference and give facility for practice.

Almost everybody has a wish to be able to draw beasts and birds, and by this time the student should be able to draw them from good flat copies, or better still, from the stuffed examples in museums, which make excellent studies if placed so as to get a profile view; otherwise placed there is too much difficulty at first with foreshortening, a subject we shall come to in dealing with object-drawing. The method to follow in such studies is similar to that to be pursued in securing general proportion of masses and block lines, although the latter should be more frequently *straight* ones. The pupil, however, must assiduously seek for the pose and action of the creature.

A New Field for Perception. Take, for example, a study of the crow, as in **14**. Observe the general proportions and note the pose and action of the bird—that it is bending down as if to peck up something, its legs in a characteristic attitude to enable it to do so, one stretched forward and the other partly raised



SUGGESTED STUDIES IN CHRYSANTHEMUM LEAF, GERANIUM, AND MARGUERITE

as if the bird were stepping forward. There is time to study all these things with the printed copy before us, but in the study of the living creature the pose or action is momentary, and only keen and rapid observation is of any avail.

This opens a new field in which the student should continue the development of his faculties of perception. Let him study all kinds of living creatures in action, and either mentally or in his sketch-book—or, better still, in both—jot down each main characteristic line expressing the action.

Drawing from Life. The first block lines for the study of the crow should be as in **15**, the chief observations concerning the relative proportions, pose and action. It will be seen that these block lines are chiefly straight; this is to obtain more vigour, real expression, and a suggestion of the anatomy of the bird in the finished drawing.

It will, moreover, enable the student to develop a good system by which, when he arrives at a more advanced stage, he can draw the human figure or any living creature in any position. Proceed with the next stage as indicated in **16**, clean up with the rubber, and finally draw with as expressive and artistic a line as possible, putting in any necessary details direct. The lines in such a study, as in studies of leaves and flowers, need not be all of one thickness, but should vary, giving strength to those lines which need it. A single stroke, even, need not be of the same thickness throughout. The lines, too, may be more broken, yet in such a way that there is no confusion, but the true representation of form or mass.

Well drawn representations of butterflies, shells, and fish will make good copies, but it would be much better if the objects themselves could be obtained and used as studies.

Pen and Ink. As considerable progress in drawing with lead pencil ought to have now been made, it will be useful to make freehand studies with pen and ink. The materials required can be obtained at such little cost, and of such good manufacture, that the student need only be careful in the selection of them, in order to provide himself with very satisfactory materials. Artists' black or liquid Indian ink are the best inks, and the pen should be flexible, so that varying thicknesses of lines may be obtained easily and quickly. As regards paper, cartridge has too soft a surface to give very good results. It is best to purchase some *hot pressed* Whatman's or Old Water Colour Society's paper, or better still, some Bristol boards.

In beginning to draw, sketch first with lead pencil the leading growth and block lines in true proportion, and then, without any preliminary sketching of details in pencil, proceed to finish with pen and ink, holding the pen so that perfect freedom of movement in any direction, and different thicknesses of line, may easily be obtained. Make all the lines as expressive as possible. The student should make frequent study of the pen-and-ink work of celebrated men. He will often find good examples in the illustrations of books by Walter Crane, Sir John Tenniel, Sir John Millais, and many other artists of our time. Among the older masters, Durer and Holbein may be mentioned, and, although their work is not all pure pen and ink drawing, much may be learnt from them about expression of line.

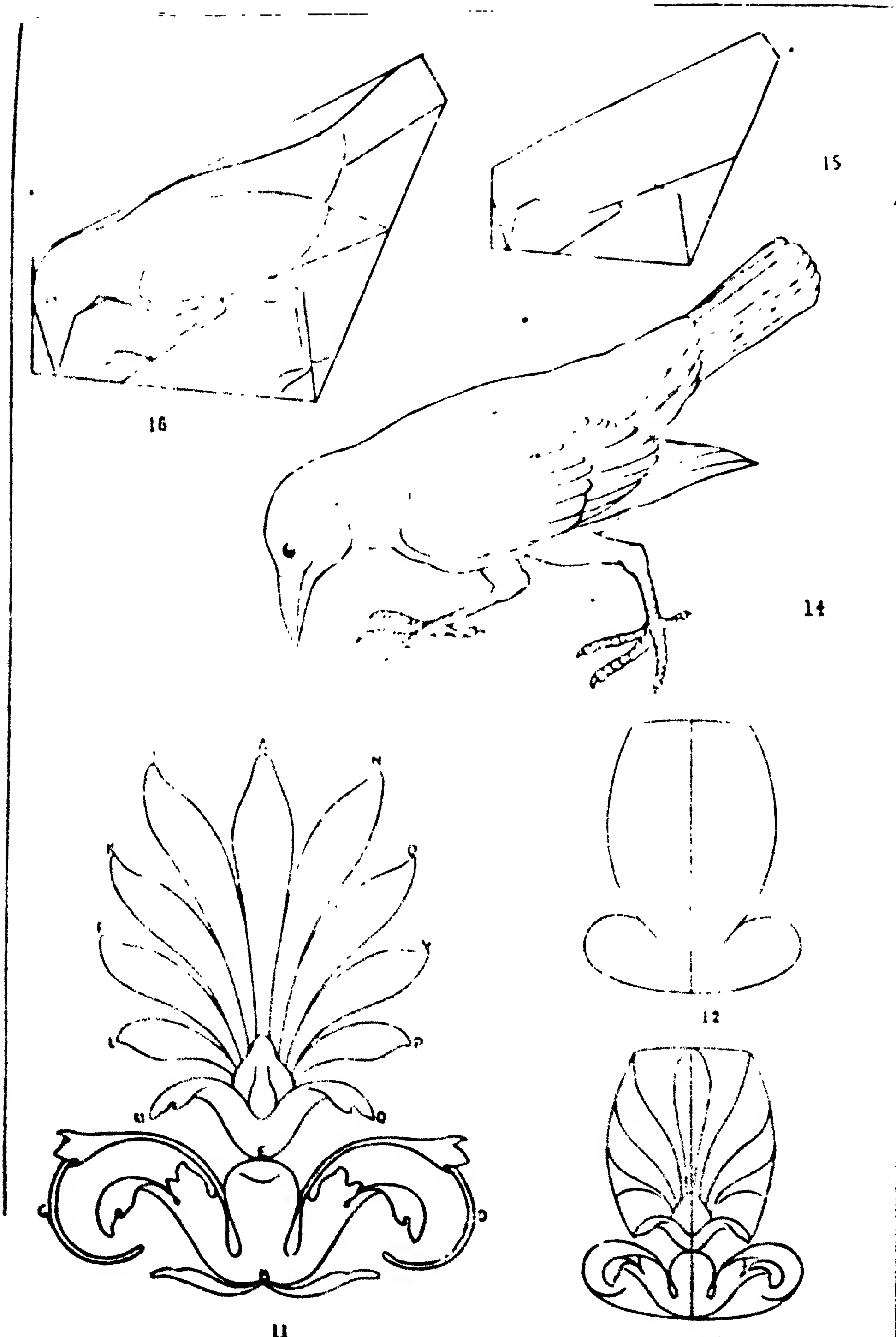
JAPANESE BRUSH DRAWING.

An Exact Impression in the Mind. It is good practice to draw direct with pen and ink without *any* pencil construction lines. This still further develops the student's powers of perception, because, knowing that he cannot easily rub out ink lines, he is the more careful to form a definite impression before drawing a single line.

Line drawing with a brush and Indian ink, sepia, is another good exercise. The brush is so flexible that many things can be expressed by it better than with pen or pencil. The brush should be a sable "writer," and not too small. To learn what may be done with a brush in line drawing, the pupil should study the many fine examples of Japanese work, in which great charm and skill are displayed. [See example on this page.]

If the student has steadily persevered, in spite of difficulties and disappointments, through the course we have taken together, he will have realised how exceedingly important it is to follow the advice about an intelligent, searching observation of the whole object before he begins to draw. He must have in his mind an exact and clear impression before he can have any hope of transferring truth to paper.

To be continued



ORNAMENTAL DRAWING: STUDY OF A CROW, HONEYSUCKLE, AND ACANTHUS.

LANGUAGES

FIVE GREAT LIVING LANGUAGES OF EUROPE

BEING

COMPLETE COURSES IN ENGLISH, FRENCH, GERMAN, SPANISH AND ITALIAN

TOGETHER WITH

A SIMPLIFIED SYSTEM OF LATIN, AND AN INTRODUCTION TO THE STUDY OF LANGUAGES

TAUGHT BY

LATIN & ENGLISH } GERALD K. HIBBERT, Master of Arts of Oxford University; Bachelor of Arts of London; Classical Master at Broadgate School, Nottingham.

FRENCH—LOUIS A. BARBÉ, B.A., French Master at Glasgow Academy.

GERMAN—P. G. KONODY, Anglo-Austrian Littérateur, and Dr. OSTEN, Dramatist.

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AN INTRODUCTORY NOTE ON THE STUDY OF LANGUAGES

LANGUAGE, or Speech, is the expression of thought by means of words.

Words are combinations of elementary sounds, to which a certain meaning is attached. The meaning of a word is what is thought of when the word is used.

A language is a collection of all the words used by people who understand one another's sounds. It cannot be too strongly emphasised that the words used by a certain people or nation, and the meanings attached thereto, are purely arbitrary—that is to say, each nation chooses for itself what words it will use, and determines what those words shall mean. For example, we in England call our staple food "bread," while the French call it *pain*. There is, of course, a *reason* for using these words ("bread" being derived from a Teutonic root, which also gives the German *brot*, and *pain* coming down from the Latin *panis* = bread), but in the beginning it was perfectly optional for our forefathers to have called bread "gypsum" or "chaw-chaw," or any other sound or combination of sounds that their fancy suggested.

Words are generally used in groups called *sentences*. A sentence is an expression of a complete thought, as "We know"; "To be or not to be; that is the question."

Grammar. The rules for grouping words in sentences are called *Grammar*. Grammar, therefore, may be defined as the science that treats of language. English grammar, French grammar, Latin grammar, and all other gammars, are those portions of the general science of language which treat of the speech of the English, French, Latin, and all o her. peoples. As with words, so with grammar; each nation settles its own. Changes of language are all decided on deliberately, though no one can say how they arise. Why, for example, does an Englishman say, "I have misunderstood it," whereas according to French grammar he would say, "I it have misunderstood"; and according to German, "I have it misunderstood"?

In writing, we represent to the eye the elementary sounds forming words, by means of marks or symbols, called letters. Each letter is the symbol of a certain sound, so that the reader, on seeing the symbol, makes the sound. Here, too, as in speaking, a nation settles for itself what letters it will use, and of what sound each letter shall be the symbol.

Words and Sentences. The grammar of any language falls naturally into two parts: *first*, that which deals with separate words; *second*, that which deals with words combined to form sentences. The first division is called *Etymology* [Greek, *etymos*, meaning "true," and *logos*, meaning "statement"]. It treats of the variations of form which words undergo to mark changes in their relations to other words, and of the manner in which they are formed out of simpler elements. There are thus two distinct branches of etymology: (*a*) the part of grammar that deals with inflexions of words; (*b*) the investigation of the derivation and origin of words. The name of *Accidence* is often given to branch *a*, either because it shows what changes may befall words [Latin, *accidere*, to befall], or because these changes are "accidentals" of words and not essentials.

The second main division of grammar, dealing with words combined in sentences, is called *Syntax* [Greek, *syntaxis*, arrangement]. The rules of syntax are statements of the ways in which the words of a sentence are related to each other. Syntax deals both with the order of words in a sentence and with the particular inflexions required in any given sentence to produce the desired meaning.

Classification of Words. The different classes in which words may be arranged are called Parts of Speech. These are the same in all languages. The English names for the eight Parts of Speech are as follow—[note that these

names are all derived from the Latin equivalents.)

1. A *Noun* (*nomen*, name) is a word used as the name of something—*e.g.* bird, *avis* (Latin), *oiseau* (French); James, Jacques.
2. An *Adjective* (*adjectivus*—that may be joined to) is a word used with a noun to describe, to measure, to count, or to indicate that for which the noun stands—*e.g. hot* days, *four* boys, *this* man.
3. A *Pronoun* (*pro*—instead of) is a word used instead of, or to avoid repeating, a noun—*e.g.* "When Elizabeth died, *she* was seventy years old."
4. A *Verb* (*verbum* = word) is a word by means of which we state something—"Birds *sing*."
5. An *Adverb* (*ad verbum* = to a word) is a word which shows how an action, state, or quality is modified or limited—"He speaks *eloquently*."
6. A *Preposition* (*prae positus*—placed before) is a word which shows how things, or their actions and attributes, are related to other things—"The Mill *on* the Floss"; "Come *unto* Me." It is usually "placed before" the noun which it governs.
7. A *Conjunction* (*con-junctio*—joining together) is a word which joins together words or sentences—*e.g.* "Man proposes, *but* God disposes"; "Come buy wine *and* milk."
8. An *Interjection* (*inter-jectus*—thrown between) is a word "thrown in" to express some feeling or emotion. It has no grammatical relation to the sentence in which it stands: "Alas!"; "Hurrah!"

The above is the usual classification: but according to derivation there are really only *three* Parts of Speech—Interjection, Verb, and Noun. For the Noun, strictly speaking, includes Adverb, Preposition, and Conjunction (which are old or disguised cases of nouns), Pronoun, Adjective, and the Infinitive Mood and Participles.

Inflexion (Latin, *inflectere* = to bend) is a change made in the form of a word to denote a modification of meaning, or to show the relationship of the word to some other word in the sentence.

Nouns and pronouns are inflected to mark Number, Gender, and Case. This inflexion is called *Declension*. Thus, in Latin there are five declensions, in Greek three, in German the Strong and the Weak declensions, etc. The old grammarians used to speak of the subject (or nominative case) as the "upright" noun, and all the other cases as "oblique."

Case. The word *Case* means "a falling," and the oblique cases were conceived of as falling away or "declining" from the nominative. Hence the declension of a noun is a statement of its cases—*i.e.* of the forms which it assumes in various relations. The full number of cases is seven.

Nominative (including the Nominative of Address, sometimes called the Vocative).
Accusative (the case of the direct object).
Dative (the case of the indirect object—*e.g.* "I give *him* a book").
Genitive (the case denoting origin or possession).
Ablative (the case denoting separation from).
Locative (the case denoting place at which).
Instrumental (the case denoting association with).

The last two became merged in the ablative in Latin, while Greek has lost both these and the ablative.

Gender. The distinction between male and female in nature is called sex. The distinction between Masculine and Feminine in words is called *Gender*. In English we adopt the natural distinctions of gender: names of animals of the male sex are masculine, names of animals of the female sex are feminine, names applied to animals of either sex are common, and names of things of neither sex are neuter. This is perfectly simple, but other languages, such as Latin, French, and German, often distinguish the gender of nouns by their endings, irrespective of meaning; thus, in German, *Madchen* = a little maid, is neuter; and in French, *la table* = the table, is feminine.

Number. Number is the difference in words to express one or more than one—singular or plural.

Comparison. Adjectives and adverbs are inflected to mark degree. This inflexion is called *Comparison*. There are three degrees of Comparison—*Positive, Comparative, Superlative*. A Positive adjective compares a thing with all other things, and ascribes to it a certain quality—*e.g.* long, *beau* (French), *altus* (Latin). A Comparative adjective compares the thing named with one other, and shows that the first has more of a certain quality than the second—*e.g* longer, *plus beau, altior*. A Superlative adjective compares the thing named with several others—at least two—and shows that it possesses a certain quality in a higher degree than any of the others—*e.g.* longest, *le plus beau, altissimus*. The same applies to adverbs.

Conjugation. Verbs are inflected to mark Voice, Mood, Tense, Number, and Person. This inflexion is called *Conjugation*. Voice is the form of the verb by which it is shown whether the subject of the sentence stands for the doer or for the sufferer of the action spoken of by the verb. Most languages have two voices—Active (where the subject of the sentence is the doer of the action), and Passive (where the subject of the sentence "suffers," or is the object of the action). Greek has a Middle or Reflexive Voice in addition. Mood is that variation of the verb used to express the mode or manner of an action or of a state of being, *e.g.* simple statement (Indicative Mood), command (Imperative), possibility (Subjunctive). When a verb has no subject expressed or implied, it is said to be in the Infinitive Mood; the other moods are finite. Tense indicates the time to which an action or event is referred; in all languages the natural

division is into Past, Present, and Future, with different varieties and shades of meanings of each. Person is a modification of the form of a verb by which it is shown whether the speaker speaks of himself (First Person), or of the person or persons addressed (Second Person), or of some other person or thing (Third Person). To "conjugate" a verb is to give all its tenses and moods, and the full Conjugation of a verb is the formation of all the inflexions and combinations used to indicate Voice, Mood, Tense, Number and Person. Thus, when we speak of the four Conjugations in Latin or French, we mean the four modes of forming the tenses in those languages. In English there are two "conjugations," Strong and Weak: the former modify the vowel-sound of the root to form the past tense (write, wrote); the latter add *-ed* or *t* to the stem (*love, lov-ed*).

Prepositions, Conjunctions, and Interjections are not inflected.

Root. These inflexions are not peculiar to English: they are found in Latin and Greek, and most of the modern European languages. Originally most words were constructed on one and the same plan. There was first of all a syllable or short combination of sounds, called a *Root*. The root is that portion of a word which it has in common with other words that relate to the same notion; it represents some fundamental idea common to many words, as GEN in *genesis, genitive, generation, gender, genus*. To the root was added a suffix or suffixes, indicating the part of speech intended, as *th* in *length*. The root and this suffix combined form the *Stem*; the stem, therefore, of a word that admits of inflexion, is that portion of the word on which the inflexions are based. This suffix is often called a stem-suffix, to distinguish it from the later suffixes appended to mark change of number, case, tense, etc., as *-s* in *boys, girls*; *-'s* in *boy's, girl's*; *-ed* in *loved*, etc.

Thus we have first the root, then the stem, finally the complete inflected word: *e.g. na* (root), *nature* (stem = root + suffix *-ture*), *natures* (stem + plural inflexion).

Analytic and Synthetic Languages. We are now in a position to understand one of the deep-lying fundamental divisions between languages. A language which is rich in inflexions, like Latin or Greek, is called *Synthetic* (Greek, "syntheticos" = "able to put together"), because it puts many meanings and relations into one word. A language which is poor in inflexions, like English or French, and uses separate words instead, is called *Analytic* (Greek, "Analyticos" = able to split up or take to pieces: *cf.* the noun "analysis").

The tendency of languages is to pass from Synthetic to Analytic, and the languages which are to-day Analytic were originally far more Synthetic, if not entirely so. We see this tendency in the passage from Latin to French, and in that from Anglo-Saxon to modern English. Anglo-Saxon, for example, was an Inflexional or Synthetic language: its nouns had five cases, and there were different declensions; adjectives were declined, and had three genders; pronouns had more forms than they have to-day, and some had a dual number, as well as a singular and plural; the verbs had more variety in the terminations of their persons. Gradually, in the three centuries following the Norman Conquest, most of these inflexions were dropped, and separate words (such as prepositions and auxiliary verbs) were used in their stead. For example, the Anglo-Saxon word "Tunge" (= tongue) was declined thus:

Case.		*Singular.*	*Plural*
Nominative	...	Tunge	Tungan
Accusative	...	Tungan	..
Genitive	.....	..	Tungena
Dative	.....	..	Tungum
Ablative	.	..	..

Prepositions. Modern English, however, marks these inflexions by the use of prepositions, *e.g.* "of the tongue," "to the tongue," etc. Similarly in Latin, for example, the different persons, numbers, tenses, moods, and voices were denoted by inflexions: *e.g. amo* (I love = *j'aime*), *amas* (thou lovest = *tu aimes*), *amat* (he loves = *il aime*). Latin, *amaretur* (he would be loved): the root is *am* (love), *a* is a stem-suffix, marking a verb; *re* denotes subjunctive mood and past tense; *t* third person, and *ur* passive voice.

The few inflexions that English does keep are all derived from Anglo-Saxon, *e.g. why* (the old ablative or instrumental case of *who*), *whilom* and *seldom* (the old dative cases plural of *whil* = time, and *seld* = rare). Probably in course of time English will become still more and more Analytic, until perhaps some day it will be an inflexionless language.

How best to Acquire a Language. There is no short cut to the acquisition of a language, that is, to the thorough understanding of it. Of course, a language can be very easily "picked up," as we say, by a short residence among the people who speak it. But merely to repeat certain sounds is not to know a language, even if we pronounce the sounds quite correctly. To know a language we must understand the why and the wherefore of all the inflexions of its words, and their relationship one with another in any sentence of that language.

Undoubtedly, therefore, the best way to *study* a language and to learn its grammar is to begin with sentences, not with single words. The unit of speech is the sentence, and we cannot fix an exact meaning to a word until we see it in a sentence. It is thus a great mistake to start learning the grammar of a language by committing to memory pages of rules and paradigms, or by confining oneself entirely to acquiring a large vocabulary of its words. It is with the sentence that the pupil should begin. When once a sufficient number of sentences has been "assimilated," it will be easy to analyse them into their component parts, and to show the relations that these bear to one another. "In this way," says Prof. Sayce, "the learner will be prevented from regarding grammar as a piece of dead mechanism or a Chinese

puzzle, of which the parts must be fitted together in accordance with certain artificial rules, and will realise that it is a living organism which has a history and a reason of its own. The method of nature and science alike is analytic; and if we would learn a foreign language properly we must learn it as we did our mother tongue, by first mastering the expression of a complete thought, and then breaking up this expression into its several elements."

The Parent of Modern Languages. The more languages one knows, the easier it becomes to acquire others; for the student of several tongues is able to "link on" the new one with the old. To a student of Latin, for example, the acquisition of French is a simple matter; he knows that in Latin *bene dormire* means "to sleep well"; so when in French he meets the words *bien dormir* he knows their meaning at once. Thus an enormous amount of memory-work is saved, and learning becomes not so much a "getting something off by heart," as a pigeon-holing of new ideas and impressions into receptacles already prepared for them. The question is often asked, "Of what use is the knowledge of Latin?" Seeing that Latin is the parent of French, Italian, Spanish, etc., and has also enormously influenced the English language, it will be easily seen that to know Latin is to accelerate the pace at which one can earn any of these languages.

LATIN

By Gerald K. Hibbert, M.A.

BEFORE beginning this course, the student should read carefully the article on the study of Languages which introduces this Section of the EDUCATOR. The student is recommended also to use a good English Latin and Latin English Dictionary.

Alphabet. The Latin Alphabet is like the English, but Latin has no "w."

Pronunciation. As Latin is a "dead" language, its pronunciation is comparatively unimportant. In our Universities and Public Schools it is usually pronounced as English. It is more correct, however, to pronounce it as French or Italian. Thus, for example:

a should be pronounced as ah (as in father).
e „ „ a (as in pay).
i „ „ e (as in meet).

It matters little which pronunciation the student adopts.

Stops and Spelling. Latin is spelt by *syllables*, as English. The Quantity of Syllables is short (˘), long (¯), or doubtful (˘̄), as the vowels are long, short, or doubtful.

The modern *Stops* are used in Latin.

FIRST LESSON

SECTION I. GRAMMAR

There are Five Declensions of Latin Nouns, known by the endings of their Genitives:

Gen. Singular — æ, i, is, ûs, ei.

Gen. Plural — Arum, Orum, Um or Ium, Uum, Erum.

Nouns are declined by Number and Case; Adjectives by Number, Case, and Gender.

The *Numbers* are two: Singular and Plural.

The *Genders* are three: Masculine, Feminine, and Neuter. In Latin the gender of a noun is often determined by its ending, not, as in English, by its meaning. Thus, *mensa* = a table, is feminine, although "table" is neuter in English.

The *Cases* are six:

		Answers the question—
1.	*Nom.*	Who or what?
2.	*Voc.*	(Case of the person addressed.)
3.	*Accus.*	Whom or what?
4.	*Gen.*	Whose or whereof?
5.	*Dat.*	To or for whom or what?
6.	*Abl.*	By, with, or from whom or what?

NOTE: The dative and ablative plural are always the same.

Nouns: First Declension: *-a* stems.

Nominative case ends in *-a*, except a few in *-as* and *-es*. Nearly all nouns ending in *-a* are of feminine gender. No neuters in this declension.

Singular.

Nom. (or subject)	mensa, *a table.*
Voc.	mensa, *O table.*
Accus. (or objective).	mensam, *a table.*
Gen.	mensæ, *of a table.*
Dat.	mensæ, *to or for a table.*
Abl.	mensā, *by, with, or from a table.*

Plural.

Nom.	mensæ, *tables.*
Voc.	mensæ, *O tables.*
Accus.	mensas, *tables.*
Gen.	mensarum, *of tables.*
Dat.	mensis, *to or for tables.*
Abl.	mensis, *by, with, or from tables.*

Use the accusative where in English we use the direct object, and the dative where we use the indirect object—*e.g.*, he gives a book (accus.) to the boy (dat.).

Like *mensa* decline almost all nouns ending in *-a*, except that *dea* (goddess) and *filia* (daughter) make dative and ablative plural *deabus* and *filiabus* (to distinguish them from the dative and ablative plural of *deus* = god, and *filius* = son).

Nouns: Second Declension: *-o* stems.

Nominative ends in *-us* and *-er* (usually masculine), or in *-um* (neuter).

	Singular.	*Plural.*
Nom.	animus (*the mind*).	animi
Voc.	anime	animi
Acc.	animum	animos
Gen.	animi	animorum
Dat.	animo	animis
Abl.	animo	animis

	Singular.	*Plural.*
Nom.	puer (*boy*)	pueri
Voc.	puer	pueri
Acc.	puerum	pueros
Gen.	pueri	puerorum
Dat.	puero	pueris
Abl.	puero	pueris
Nom.	faber (*workman*)	fabri
Voc.	faber	fabri
Acc.	fabrum	fabros
Gen.	fabri	fabrorum
Dat.	fabro	fabris
Abl.	fabro	fabris
Nom.	donum (*gift*)	dona
Voc.	donum	dona
Acc.	donum	dona
Gen.	doni	donorum
Dat.	dono	donis
Abl.	dono	donis

NOTE: The vocative of *Deus* (God) is *Deus*: nominative plural, *Di*; dative and ablative plural, *Dis*. The vocative of *filius* (son) is *fili*. *Vir* (a man) is declined like *puer*; accusative, *virum*; genitive, *viri*; dative and ablative, *viro*.

Adjectives: First and Second Declensions. Adjectives of three endings in *us, a, um* (masculine, feminine, neuter) or *er, a, um*, follow the Second and First declensions of nouns. Decline the masculine like *animus*, *puer*, or *faber*; the feminine like *mensa*; the neuter like *donum*. Thus, *bonus* (good):

	Masc.	*Fem.*	*Neut.*
Nom.	bonus	bona	bonum
Voc.	bone	bona	bonum
Acc.	bonum	bonam	bonum, *etc.*

Also:

Nom.	tener (*tender*)	tenera	tenerum
Voc.	tener	tenera	tenerum
Acc.	tenerum	teneram	tenerum, *etc.*
Nom.	niger (*black*)	nigra	nigrum
Voc.	niger	nigra	nigrum
Acc.	nigrum	nigram	nigrum, *etc.*

Prepositions. These are indeclinable. In Latin they are used with either the accusative or the ablative case.

The following take the accusative:

ante, before. *apud*, among, near.
ad, to, at. *adversus*, opposite to.

circum or *circa*, round, on both sides of
citra or *cis*, this side of.

erga, towards. *contra*, against.
inter, among, between. *extra*, outside of.

infra, below. *intra*, within.
juxta, close to. *ob*, on account of.

penes, in the power of. *pone*, behind (rare).
post, behind, after. *praeter*, beyond, except

prope, near to.
propter, on account of, thanks to.
per, through.

secundum, along. *supra*, above, beyond.
versus, in the direction of.

ultra, beyond. *trans*, across.

The following take the ablative:

a (*ab*, *abs*), by, with, from. *cum*, with. and *de*, down from; concerning

coram, in the presence of. *pro*, in front of, on behalf of. with *ex* or *e*, out of, from

tenus, as far as. *sine*, without. also *prae*, in front of

The four following take the accusative when they denote "motion towards," but the ablative when they denote "place at":

Sub and *Subter* (1) with accusative, "up to": *sub muros* up to the walls.
(2) with ablative, "beneath"

Super (1) with accusative, "above," "beyond", as, *super Indos* beyond the Indians.
(2) with ablative, "on"

In (1) with accusative, "into, to, against"
(2) with ablative, "in, at, on"

Prepositions usually come before their nouns, except *tenus* and *versus*, e.g. *Romam versus*, in the direction of Rome. *Tenus* can be used with the genitive. Also write *mecum*, *tecum* (with me, with thee), not *cum me*. (*See* Pronouns, next lesson.)

Verb "to be."

INDICATIVE MOOD.

	Singular	*Plural.*
PRESENT TENSE		
1st person	sum, *I am*	sumus, *we are*
2nd person	es, *thou art*	estis, *ye are*
3rd person	est, *he, she*, or *it is*	sunt, *they are*
FUTURE TENSE		
1st person	ero, *I shall be*, etc.	erimus
2nd person	eris	eritis
3rd person	erit	erunt
IMPERFECT TENSE—		
1st person	eram, *I was*, etc.	eramus
2nd person	eras	eratis
3rd person	erat	erant
PERFECT TENSE—		
1st person	fui, *I have been*, etc.	fuimus
2nd person	fuisti	fuistis
3rd person	fuit	fuerunt
FUTURE PERFECT—		
1st person	fuero, *I shall have been*, etc.	fuerimus
2nd person	fueris	fueritis
3rd person	fuerit	fuerint
PLUPERFECT—		
1st person	fueram, *I had been*, etc.	fueramus
2nd person	fueras	fueratis
3rd person	fuerat	fuerant

SUBJUNCTIVE MOOD.

	Singular.	*Plural.*
PRESENT—		
1st person	sim, *I may be, or let me be*	simus
2nd person	sis, *thou mayest be*	sitis
3rd person	sit, *he may be, or let him be*	sint
IMPERFECT		
1st person	essem, *I might be*	essemus
2nd person	esses	essetis
3rd person	esset	essent
PERFECT—		
1st person	fuerim, *I may have been*	fuerimus
2nd person	fueris	fueritis
3rd person	fuerit	fuerint
PLUPERFECT—		
1st person	fuissem, *I should or might have been*	fuissemus
2nd person	fuisses	fuissetis
3rd person	fuisset	fuissent

IMPERATIVE MOOD.

PRESENT		
	es, *be thou*	este, *be ye*
FUTURE		
	esto, *thou must be*	estote, *ye must be*
	esto, *he must be*	sunto

INFINITIVE MOOD.

PRESENT—esse, *to be*.

PERFECT AND PLUPERFECT—fuisse, *to have been*.

FUTURE PARTICIPLE—futurus, *about to be*.

FUTURE INFINITIVE—futurus esse, *to be about to be*.

NOTE.—To form the Imperfect Subjunctive of a verb, add *m* to Present Infinitive: *esse, essem*. Likewise add *m* to Perfect Infinitive to form Pluperfect Subjunctive—*fuisse, fuissem*.

SECTION II—SYNTAX

Rule 1. A finite verb agrees with its subject (or its nominative case) in number and person. [This does not apply to the infinitive mood.] For example, *Servus adest*, the slave is present. *Adsum*, I am present. *Magistri aderunt*, the masters will be present. [*Adsum* is a compound of the preposition *ad* and *sum*.]

Rule 2. An adjective (or pronoun or participle) agrees in number, gender, and case with the substantive to which it is attached—*e.g.*, *Cara est patria*, dear is one's native-land. *Habeo* (= I have) *multos equos*, I have many horses.

Rule 3. A substantive may have another substantive added to explain or describe it; the latter is then said to be in *apposition* to the former, and must agree with it in case—*e.g.*, *Filius Victoriæ, reginæ Britannorum, rex erit* = the son of Victoria, queen of the Britons, will be king. [*Reginæ* is genitive, in apposition to *Victoriæ*.]

NOTE: Any finite part of the verb *sum* is usually a copula or link, linking the complement to the subject—thus, *Edwardus est rex* = Edward is king. The complement will, of course, agree with the subject in *number* and *case*, and (if the complement be an adjective) in *gender* as well—*e.g.*, *Bellum erit longum* = the war will be long.

VOCABULARY TO LEARN BY HEART.

War—Bellum, *genitive* belli	**Wave**—Unda, -æ.
Romans—Romani, *genitive*, Romanorum	**Friend**—Amicus, -i.
Ally—Socius, -i.	**Pear-tree**—Pirus, -i.
Gauls—Galli, -orum	**Slave**—Servus, -i.
Long—Longus, -a, -um	**Town**—Oppidum, -i.
Path—Via, -æ	**Weak**—Invalidus, -a, -um
Wood—Silva, -æ	**Broad**—Latus, -a, -um.
If—Si (with *subjunctive*)	**Straight**—Rectus, -a, -um
Not—Non	**Britain**—Britannia.
And—Et	**Book**—Liber, libri
Miserable—Miser, misera, miserum	**Garden**—Hortus, -i.
Island—Insula	**Crown**—Corona, -æ.
	Gate—Porta, -æ
	Strong—Validus, -a, -um

The student is advised to write out the following sentences in Latin, and then compare them with the key given below, correcting his own version thereby and being careful not to refer to the key until he has made an independent effort to translate for himself.

1. The war between the Romans and the allies of the Gauls will be a long one (omit "one").
2. The path to (use preposition *ad*) the wood is broad and straight.
3. If she had been good ("she" need not be expressed; it will be conveyed by the gender of the adjective "good"), she would not have been miserable.
4. The island of Britain (say, "the island Britain," Britain being in apposition to island) is in the midst of (say "among") the waves.
5. The boy's book (the book of the boy) was the gift of (his) friend.
6. In the garden there had been a pear-tree.
7. I give (*do*) a crown to the good slave.
8. I walk (*ambulo*) to the gates of the town.
9. Let us be friends and allies to the weak slaves.
10. "To be" is good (neuter); "to have been" is better (*melius*, neuter of *melior* = better).

KEY TO THE ABOVE SENTENCES.

1. Bellum inter Romanos et socios Gallorum erit longum.
2. Via ad silvam est lata et recta.
3. Si bona fuisset, non misera fuisset.
4. Insula Britannia est inter undas.
5. Pueri liber erat amici donum.
6. In horto fuerat pirus.
7. Do coronam bono servo (indirect object).
8. Ambulo ad portas oppidi. [NOTE: The dative, *portis*, would be wrong here; "to the gates" is not indirect object. Wherever "to" expresses "motion to," use *in* or *ad* with accusative.]
9. Simus amici et socii invalidis servis.
10. Esse est bonum: melius (est) fuisse.

SECTION III. TRANSLATION.

The student should translate the following sentences into English, first mastering the words in this vocabulary:

VOCABULARY TO LEARN BY HEART.

Probus, -a, -um—Good, honest.
Beatus, -a, -um—Happy.
Ut In order that (takes the Subjunctive).
Fluvius, -i—River.
Poeta, -æ (masc.)—Poet.
Humerus, -i—Shoulder.
Verus, -a, -um—True.
Amicitia, -æ—Friendship.
Castrum, -i—Fort (in pl. *castra* = a camp).
Albus, -a, -um—White.
Ludus, -i—School (also = play, game).
Parvus, -a, -um—Small.
Discipulus, -i—Scholar, pupil.
Lætus, -a, -um—Joyful.
Dominus, -i—Master.
Pallium, -i—Cloak.

1. Este probi ut beati sitis.
2. Oppidum Londinium est prope latum fluvium.
3. Servus sit penes dominum.
4. Vergilius erat poeta apud Romanos.
5. Pallium fuerat in humeris reginæ.
6. Vera amicitia est donum deorum.
7. Castrum Romanorum erat trans fluvium.
8. Si albi fuissent, non nigri fuissent.
9. In ludo erant parvi discipuli.
10. Læti sunt animi bonorum.

KEY TO THE ABOVE SENTENCES.

1. Be honest in order that you may be happy.
2. The town of London (note omission of "of") is near a broad river.
3. Let the slave be in the power of his master.
4. Vergil was a poet among the Romans.
5. The cloak had been on the queen's shoulders.
6. True friendship is the gift of the gods.
7. The fort of the Romans was across the river.
8. If they had been white (men) they would not have been black.
9. In the school there were small scholars.
10. Joyful are the minds of the good (men).

(NOTE: "Man" and "men" are often not expressed in Latin—*e.g. boni* = the good.)

The beginner is recommended, after writing out the above exercises, to reverse the process and turn the sentences immediately above this note into Latin, and the sentences beginning *Bellum inter Romanos* into English.

To be continued.

ENGLISH

By Gerald K. Hibbert, M.A.

THE ALPHABET. The English Alphabet is the ordinary Roman alphabet, with the addition of the letter w. It consists of twenty-six letters, which are written both as small letters and as capitals.

CAPITALS. A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, Q, R, S, T, U, V, W, X, Y, Z.

SMALL. a, b, c, d, e, f, g, h, i, j, k, l, m, n, o, p, q, r, s, t, u, v, w, x, y, z.

Capital letters are used at the beginning of proper names; also at the beginning of every new sentence, and of every line of poetry. The pronoun I and the interjection O are always capitals. Capitals are also used when speaking of the Divine Being, *e.g.* Thou, He, and in such expressions as His Majesty, etc.

The English alphabet is both redundant and defective: redundant because it contains three letters (c, q, x) indicating sounds which are also indicated by other letters (c = k or s, q = k, x = ks or gs): defective because there are only twenty-six letters (twenty-three really) to express at least thirty-eight sounds. For the fifteen sounds which have no special letters, we use certain combinations of letters, as *ng, ee, au, sh, ch*, etc. We want a new alphabet of at least thirty-eight letters, one for each sound.

Vowels. The letters a, e, i, o, u are called *Vowels* (Lat., *vocalis* = soundable), because they can be fully sounded by themselves, and with no check in the passage of the breath. The remaining letters are called *Consonants* ("sounding with"), because they cannot be fully articulated without a vowel sound along with them: they are voice checks.

W and *y* are semi-vowels; when they are followed by a vowel sound in the same syllable, they are consonants, as *world, yield*. When a vowel precedes them in the same syllable they combine with it to form either a diphthong (see below), or a simple vowel sound, as *few, buy*. *Y* is a pure vowel when followed by a consonant, as *Ygdrasil*: this was its original use, it was first used as a consonant after the Norman Conquest.

When two vowel sounds are pronounced as one syllable we have a *diphthong* ("double sound"). The four true diphthongs are:

1. *i*, as in *bind, find* (*cf.* the same sound in *aye*). This sound = *a* + *i*.
2. *oi* or *oy*, as in *hoist, boy, buoy*. It = the sound of *a* in *fall* + *e*.
3. *eu*, as in *euphony*: this diphthong is also found in *mute, cue, chew, beauty, suit*.
4. *ou* or *ow*, as in *how, pound*.

NOTE. In cases where two vowels are written, but only one pronounced (*gauge, boat, men*), we have not a proper diphthong.

The primary vowel sounds are *i* (as in *pit*), *ā* (as in *far*), and *ū* (as in *pull*): all the others are modifications of these.

The simple vowel sounds in English, as given by Mason, are thirteen, viz.:

1. The sounds of *a* in *tall, father, fate, fat*;
2. The sounds of *e* in *met* and *mete*;
3. The sound of *i* in *pin*;
4. The sounds of *o* in *not* and *note*;
5. The sounds of *u* in *rule, pull, fur*, and *but*.

Consonants. These are classified thus:

1. LIQUIDS: *l, m, n, r*. They run smoothly and easily into the sounds of certain other consonants: *e.g. mb, mp, nd, nt*, etc.
2. SIBILANTS (hissing letters): *s, x, z*, soft *ch, sh*, and *j* (or soft *g*).

3. MUTES = all the remaining consonants, except *h*. These are divided into three classes, according to the part of the mouth or throat chiefly used in their pronunciation:

   a. LABIALS (*labium* = lip): *b*, *p*, *f*, and *v*.

   b. DENTALS (*dens* = tooth): *d*, *t*, and *th* (*th* is sharp in *think*, flat in *this*).

   c. GUTTURALS (*guttur* = throat): *g*, *k*, hard *c* and *ch* (as in *loch*), and *gh*.

NOTE. *C is hard (= k) before a, o, u (cat, cot, cut); but soft (= s) before e, i, y (cedar, cider, cyst). In Old English c was always hard, and k was a superfluous letter. The soft sound of c is due to French influence after the Norman Conquest. Similarly with g: it is hard before a, o, u; and sometimes hard and sometimes soft before e and i (get, give, gem, giant). Ch and gh are now used as aspirates only in Lowland Scotch. Ch is usually soft in English (much, child; and = sh in machine); it is sometimes hard (ache). Gh in English is (1) silent, as though, (2) = f, as enough.*

H forms a class by itself. It resembles a consonant in that it cannot be articulated by itself, but it is not properly a consonant. It is a simple impulse of the breath, and is called an *aspirate* (*spiro* = I breathe). It was originally a guttural, and still retains this sound in Scotland and the north of England. In some words *h* is silent (heir, hour, honour); in certain others it is doubtful (*e.g.* some people say *hospital*, others *'ospital*). In words beginning with *wh* (who, why), the *h* should be sounded, *e.g.*, *what* is not pronounced as *wot*, but as *h wot*.

Q, as has been said, is a superfluous letter. It is always followed by *u*, and in Old English this sound was expressed by *cw* (*cwen* = queen).

Defects in English Spelling. A perfect system of spelling or writing would be *phonetic*, *i.e.* would indicate exactly the sounds made in speaking. For this purpose it is necessary:

1. That there should be a letter for each spoken sound;
2. That each letter should stand for only one sound;
3. That, in writing a word, no sound should be omitted and no unpronounced letters should be added.

English spelling breaks all these rules:

1. As there are only twenty-three letters for thirty-eight sounds, there are fifteen sounds without corresponding letters.
2. The letter *a*, for example, represents five simple vowel sounds, as in *fate*, *fall*, *far*, *fat*, *want*; so does *e* (*mete*, *pet*, *herd*, *clerk*, *pretty*); *i* represents two simple sounds (*pit*, *fir*) and one diphthongal (*bite*); *o* represents three sounds (*poke*, *pot*, *for*); *u* represents four (*rude*, *pull*, *fun*, *fur*). *Cf.* *his* and *this*; *dough* and *cough*.
3. Letters are often written which are not pronounced; these are useless as signals of the spoken word:

   E.g., *c* is useless in *duck*, *scene*.
   g „ „ *gnat*, *reign*.
   k „ „ *knee*, *know*.

Syllable. This consists of a single vowel or a collection of letters pronounced together, and has only one vowel sound. Words consisting of one, two, or three syllables are called respectively monosyllables, disyllables, and trisyllables; words of more than three syllables are called polysyllables (Gk., *polys*, "many").

In dividing a word into syllables we must as far as possible indicate the significant parts of which the word is composed, *e.g.* trans-act, not tran-sact; e-rect, not er-ect. There is, however, a limitation to this rule, for words must be divided in writing according to the way in which the elementary sounds are grouped in speaking, *i.e.* the division is usually made after the vowel, and the following consonant is carried on to the next syllable, *e.g.* hu-mour, fa-cing.

Accent is the stress of the voice upon a syllable as cataract, pervérsion, corróde. Difference of accent is often the only distinction between nouns and verbs, *e.g.* rébel and rebél, prógress and progréss. Many words have changed their accent, and the tendency of English is to throw the accent back towards the beginning of a word. Thus Shakespere uses *contráry*, Milton *blasphémous*, Pope *compénsated* and *efföct*, etc.

Parts of Speech. They are eight in number:

1. Noun	5. Adverb.
2. Adjective (and Article).	6. Preposition.
3. Pronoun.	7. Conjunction.
4. Verb.	8. Interjection.

Noun. A word used as the name of something (*nomen* = name).

CLASSIFICATION OF NOUNS. There are two main classes of nouns: 1. PROPER NOUNS; 2. COMMON NOUNS.

1. A *Proper Noun* is a name appropriated (Latin, *proprium*) to one particular thing or person, *e.g.* Joan of Arc, Abraham, John Jones, the Cæsars, Mont Blanc.

2. A *Common Noun* is a name which all things of the same kind have in common (*communis* = shared by several). All nouns not proper are common. Examples: cat, town, coal, water, book.

NOTE. Proper nouns may be converted into common, *e.g.* "he is the *Rupert* of debate." Similarly, a common noun may become proper, *e.g.* "I am going up to *Town*" (meaning "London").

Common nouns are subdivided into:

1. *Ordinary Class Names*, *i.e.* names belonging to each individual of a class, or to each portion of some sort of material, *e.g.* tree, iron.

2. *Collective Nouns*, denoting a number of persons or things forming one body, *e.g.* committee, jury, herd. In the plural such nouns stand for several similar collections: *e.g.* the Parliaments of Europe. As a rule, a collective noun has its verb in the singular: "the Government has abdicated"; but when attention is directed to the individuals composing the subject, the verb is plural: *e.g.* "the jury were right in finding the prisoner guilty."

3. *Abstract Nouns*, denoting not objects, but quality, action, or state, *e.g.* *drowsiness*, *walking*, *manhood*. Also names of arts and sciences, as *music*, *biology*.

INFLEXIONS OF NOUNS. Nouns are inflected to mark Gender, Number, and Case. This is called Declension.

Gender. Gender distinctions in English are beautifully simple. All names of animals of the male sex are masculine; names of animals of the female sex are feminine; names applied to animals of either sex are of common gender (*sheep, swan*); and names of things of neither sex are neuter. This is a *natural* distinction of gender based on a *natural* distinction of sex. (In other languages, gender becomes a merely grammatical distinction; thus, in Latin, *mensa*, = a table, is feminine because it ends in *-a*.) Of course, when lifeless things are personified, they cease to be of neuter gender, and are made masculine or feminine: *e.g.* the moon is spoken of as *she*; the sun as *he*; a ship as *she*.

There are three ways of indicating difference of gender in nouns.

1. *By Inflexion*, the gender being indicated by the termination of the word.

(a) Different suffixes used for masculine and feminine:

Masculine.	*Feminine.*
Sorcerer	Sorceress
Murderer	Murderess
Governor (ruler)	Governess (instructress)
Emperor	Empress

NOTE. The ending *-er* is a true English suffix; its feminine was *-ster*, of which *spinster* is the only example now in use. "Songster" and "Seamster" were originally feminine, so "songstress" and "seamstress" are double feminines. Therefore although certain words ending in *-ster* are now used as masculine, they once denoted occupations carried on by women, *e.g.* tapster (bar-maid), maltster, brewster, huckster, baxter (bake), webster (weave), etc.

(b) The feminine formed from the masculine by adding feminine suffixes:

(i) By far the commonest of these is *-ess*, *e.g* actor, actress; hunter, huntress; negro, negress; votary, votaress; peer, peeress; Jew, Jewess; abbott, abbess (shortened from "abbadess"); lad, lass (laddess); master, mistress (vowel modified); duke, duchess (French, *duchesse*); marquis, marchioness

(ii) *-en*, an old Teutonic feminine suffix, of which only one pure English example remains: *vixen*, from *fox* (German, Füchsin).

(iii) The following suffixes are foreign importations: *-trix* (executrix), *-ine* (heroine), *-ina* (czarina), *-a* (sultana)

NOTE. In the following words the masculine seems formed from the feminine:

Masculine.	*Feminine.*
Widower	Widow
Bridegroom (groom = man)	Bride
Gander	Goose (old form *gans*)

2. The second way of indicating difference in gender is by prefixing or affixing a word significant of sex to nouns of common gender:

Masculine.	*Feminine.*
Cock-bird	Hen bird
He goat	She goat
Man-servant	Maid servant
Buck rabbit	Doe rabbit
Pea-cock	Pea hen

3. The third way of indicating difference of gender is by using distinct words:

Masculine.	*Feminine*
Man (originally common)	Woman (wife man)
Father (one who feeds)	Mother (bringer forth)
Son	Daughter ("milkmaid")
Husband (house bonda, or manager)	Wife (a woman)
King (Cyning)	Queen (female, or mother)
Lord (loaf ward, hlaford)	Lady (hlaefdige)
Monk (monachus, a lonely dweller) / Friar (brother)	Nun (nonna = grand mother)
Drake (king of the ducks)	Duck (diver)
Uncle	Aunt
Wizard	Witch
Sir (senior)	Madam (mea domina = my lady)

To be continued

FRENCH

By Louis A. Barbé, B.A.

THE French alphabet, like the English, consists of twenty-six letters, including W, which occurs in a few words of foreign origin.

The names of these letters are:

A .. called	āh	O .. called	o
B .. „	bey	P .. „	pey
C .. „	cey	Q .. „	kü (see U below)
D .. „	dey	R .. called	érr
E .. „	ey	S .. „	ess
F .. „	eff	T .. „	tey
G .. „	jay without the initial *d*-sound	U .. „	ü (pronounced as the vowel sound in "rumour," but short)
H .. called	āhsh	V .. called	vey
I .. „	ee	W .. „	doobl vey
J .. „	jēe without initial *d*-sound	X .. „	icks
K .. called	kah	Y .. „	ee-greck
L .. „	ell	Z .. „	zed
M .. „	emm		
N .. „	enn		

The Vowels. The vowels are A, E, I, O, U, Y. Let us consider them in their order.

A.

In pronunciation the vowel *A* may have either a long or a short sound. The long sound resembles that of the English *a* in *father*. The short sound has no absolute equivalent in English. The nearest approach to it may be got by pronouncing such words as *bat*, *cat*, with the mouth well open. *A* is occasionally silent, as in *août*, (*August*), pronounced ōō.

E.

There are three kinds of *E*—mute *e*, closed *e*, and open *e*. When the final letter of a word of more than one syllable, *e* mute is really silent; but it causes the preceding consonants to

be sounded clearly. Thus the proper pronunciation of *porte* is got by making the *t* felt.

In the body of a word *e* mute is practically dropped in ordinary conversation. Thus *relâche*, pronounced *r'lahsh*.

In monosyllabic words, such as *je* (I), *me* (me), *le* (the), the *e*, though mute, is felt slightly. The sound has no exact English equivalent. It has some resemblance to the slurred sound of *e*, as colloquially pronounced in such a combination as *the boy*.

In attempting to indicate this shade of sound in the phonetic explanations throughout this Course it will be written *ĕ*. This is also the sound of *eu*, as in *feu*, pronounced *fĕ*, fire; *bleu*, pronounced *blĕ*, blue; *œu*, as in *bœuf*, pronounced *ĕf*, ox; *œuf*, pronounced *ĕf*, egg; *cœur*, pronounced *kĕr*, heart; *chœur*, pronounced *kĕr*, choir; *nœud*, pronounced *nĕ*, knot; *œuvre*, pronounced *ĕvr*, work; *sœur*, pronounced *sĕr*, sister; *vœu*, pronounced *vĕ*, wish; and of *œ*, as in *œil*, pronounced *ĕ-yĕ*, eye.

E has the sound of *a* in *femme*, pronounced *fam*, woman.

E remains mute when followed by *s*, and, in verbs, by *nt*. Thus, *porte*, *portes*, and *portent* are all pronounced *port'*. The sound of closed *e* is approximately that of *e* in *bet*, *met*. It is indicated by an acute accent thus, *é*. Open *e* has no exact counterpart in English. There is an approach to it in the *a* of *fame*. The sound has two modifications, the one rather shorter than the other. The one occurs in monosyllabic words ending in *es*, as *les*, the plural of the definite article *le*, and in *mes*, *ces*, *ses*, the plurals of the adjectives my, this, and his. It is also indicated by the grave accent, thus *è*, as in *père*, pronounced *pairr* (father). The circumflex accent, *ê*, commonly marks the other, as *tête*, pronounced *tate* (head).

I.

The sound of the vowel *I* resembles that of the English *ee* in *feel*, as *île* (island). There is a shorter, but not essentially different sound of the letter, as in *il* (he).

O.

The vowel *O* has a clearer and more definite sound than in English. When long, its length is about that of the English *o* in *rose* or *shore*. As far as mere length goes, *o* short is equivalent to *o* in *not*.

U.

There is nothing in English resembling the French sound of *U*. To produce it, keep the lips well rounded and pursed while attempting to pronounce English *e*. The actual sound of the vowel is not materially affected by its being short or long.

Y.

Y is equivalent to I at the beginning of a word, as *yeux*, pronounced *ee-e* (eyes), or after a consonant, as *style*, pronounced *steel*. When preceded by a vowel it is pronounced like *ii*; thus *pays* (country), *citoyen* (citizen), *abbaye* (abbey), become *pay-ee*, *seet-wo-yaww'**, *ab-ay-ee*.

* See explanation of ' symbol under M and N.

For the proper pronunciation of the French vowels, it is of great importance to remember that each of them represents one single definite sound, whether short or long, and not a combination of vowel sounds as is sometimes the case in English.

The names of the vowels when used as substantives are all of the masculine gender. Of the consonants, *f*, *h*, *l*, *m*, *n*, *r*, *s* are feminine, but all the others are masculine.

Vowel Sounds. The vowel sounds are represented, not only by single vowels, but also, in certain cases, by combinations of vowels. Thus:

1. The sound of A occurs in *Oi*, in which, however, it is preceded by, and closely connected with *ou*: *oi* = *oua*.

2. The sound of mute *e* is produced by *ai* in certain parts of the verb *faire* (to do), as *faisant*, *nous faisons*, *je faisais*.

The closed sound of *e* (*é*) is sometimes represented by *er* and by *ai*, as in *aimer*, *j'aimai*.

The open sound of *e* (*è*) is also produced by *ais* and by *ei*, as in *mais*, pronounced *may* (but), *peine*, pronounced *pen* (pain).

3. The long and short *o*-sounds have equivalents in *au*, *eau*, *aux*, *eaux*, as in *Paul*, *mauvais* (bad) *bateau* (boat) *aube* (dawn) *châteaux* (castle).

4. The sound of *U* is represented by *eu* in certain parts of the verb *avoir*, as in *j'eus eu*, pronounced *ji-zü*, I had had.

The Consonants. There are twenty consonants, which it is important that we should now consider.

B.

The consonant *B* is pronounced as in English, thus, *barbe* (beard). As a final, it is not sounded in *plomb*, pronounced *plon'**, lead.

C.

C has the hard sound of *k* before the vowels *a*, *o*, *u*, as *cap*, pronounced *kahp*, cape; *cou*, pronounced *koo*, neck; before consonants, as *classe*, pronounced *klas*, class; *cri*, pronounced *kree*, cry; and at the end of words, as *avec* (with), *bec* (beak), *parc* (park).

It has the soft sound of *s* before the vowels *e*, *i*, *y*, as *ceci*, pronounced *sesee*, this; *cité*, pronounced *seetey*, city; *cyprès*, pronounced *seeprè*, cypress.

In *second*, pronounced *ze-gon'*, and its derivatives, *c* is pronounced like *g*.

C after *s* at the beginning of a word or syllable is not sounded; thus, *science*, *scène*, are pronounced *see-awn's*, *sane*.

C final is silent in a few words, of which the most usual are *banc*, pronounced *bawn'*, bench; *flanc*, pronounced *flawn'*, side; *blanc*, pronounced *blawn'*, white; *clerc*, pronounced *clare*, clerk; *franc*, pronounced *frawn'*, franc; *tronc*, pronounced *tron'*, trunk; *porc*, pronounced *por*, pig.

Ch has the hard sound of *k* in most words derived from the Greek. It has the soft sound of *sh* in *archevêque*, pronounced *ahrsh-ay-vake*, archbishop; *archipel*, pronounced *ahrsh-ee-pel*, archipelago.

D.

D, as the first letter of a word or syllable, is sounded as in English, thus: *dôme* (dome). As a final it is usually silent, as in *bord*, pronounced *bor*, edge; but when linked in pronunciation to a word beginning with a vowel or a mute *h*, it assumes the sound of *t*; *grand ami* becomes *grawn'-tami*, great friend. This linking does not affect the sound of *d* in words in which it is pronounced as a final, as *sud* (south). Thus, we say *sud-est* (south-east) with a *d*-sound.

F.

Initial *F* has the same sound as in English. As a final it is usually sounded, as *vif* (lively), *bref* (brief), *serf* (serf). The exceptions to this are *clef*, pronounced *klēy*, key; *cerf*, pronounced *sair*, stag; and *cerf-volant*, pronounced *sair-volawn'*, kite; *chef-d'œuvre*, pronounced *shēy-devrr*, masterpiece, and the plurals *œufs* and *bœufs*, eggs and oxen. Authorities differ as to whether it is silent or sounded in the singular *nerf*. All agree as to its being silent in the plural *nerfs*. In the numeral *neuf* (nine), the *f* is silent before a word beginning with a consonant or *h* aspirate, if that word be multiplied by the numeral; but not otherwise. Thus, *neuf mois* (nine months) is pronounced *nĕ-mwa*, whilst in *le neuf janvier* (the ninth of January) the final *f* is heard. In the same numeral the final *f* assumes the sound of *v* before a multiplied word beginning with a vowel or *h* mute, as in *neuf heures*, which becomes *nev-ĕrr*.

G and J.

G has a hard sound, as in the English words *gave*, *grave*, *glimpse*, when it comes before *a*, *o*, *u*, *l*, and *r*, as in *galon*, pronounced *galon'*, gallon; *gosier*, pronounced *goz-ee-ey*, throat; *gloire*, pronounced *glwarr*, glory; *agréable*, pronounced *a grey abl*, agreeable.

In order to get the same guttural sound before *e* and *i*, the *g* must be followed by *u*, which, however, is not otherwise sounded, thus: *guérir*, pronounced *ghereer*, to cure; *guide*, pronounced *gheed*, guide. There are a few words in which the *u* of *gui* and *gue* is felt. These words are—*aiguille*,* pronounced *egg-wee-ĕ*, needle; *aiguillon*,* pronounced *egg-wee-on'*, goad; *aiguiser*, pronounced *egg-wee-zēy*, to sharpen; *arguer*, pronounced *ahr-guēy*, to argue; and the proper nouns Guise, pronounced *Gweez* and *Guizot*, pronounced *Gweezo*.

The nearest equivalent to the soft sound of *G* is represented by *si* and *su* in such English words as *vision*, *measure*. It naturally assumes this sound before *e* and *i*, as in *gentil*, pronounced *jawn'-tēē* (nice). When it is required to give it this soft sound before *a* or *o*, an intermediate *e* must be introduced, as in *geai*, pronounced *jey*, jay.

The sound of *J* is identical with this soft sound of *g*, as in *joli* (pretty), *jeune* (young).

The *d*-sound which in English constitutes a part of the pronunciation of *j*, and sometimes of *g*, as in *Jane*, *George*, must be carefully avoided in French.

Final *g* is silent in *faubourg*, pronounced *fo-boor*, suburb; *doigt*, pronounced *dwa*, finger; *vingt*, pronounced *van'*, twenty; *étang*, pronounced *etawn'*, pond; *hareng*, pronounced *arawn'*, herring; *long*, pronounced *lon'*, long; *sang*, pronounced *sawn'*, blood; *rang*, pronounced *rawn'*, row.

When final *g* is carried on to a word beginning with a vowel, it takes the sound of *k*, thus; *sang et eau* is pronounced *sawn'key-ō*, blood and water.

H.

Initial *H* is not sounded; but in words in which it is said to be aspirated, it prevents the elision or dropping of the final vowel, and the carrying on or linking of the final consonant in certain words that precede them. Thus, *h* being aspirated in *héros* (hero) and *hache* (hatchet), we say *le héros*, *la hache*, *les héros*, *les haches*. Mute *h* is non-existent for purposes of pronunciation, so that the words in which it occurs practically begin with a vowel, and consequently allow both elision and linking. Thus, with *homme*, pronounced *om* (man) and *histoire*, pronounced *ees-twahr* (history), we get *l'homme*, *l'histoire*, and we pronounce *les hommes*, *les histoires* as *lé z (h)ŏm*, *le z (h)ees twahr*. H, though aspirated in *héros*, is silent in all its derivatives: *l'héroïne*, *l'héroïsme*, etc.

K.

The letter *K* is found only in a few words of foreign—mainly Greek—origin. Its pronunciation offers no difficulty.

L.

The simple and natural pronunciation of *L* is the same as in English: *laurier*, pronounced *lor-ee-ey*, laurel; *chaloupe*, pronounced *shaloop*, shallop.

Final *l* is not sounded in *baril* (barrel), *chenil* (kennel), *coutil* (duck), *cul de sac* (blind road), *fusil* (gun), *gril* (gridiron), *nombril* (navel), *outil* (tool), *persil* (parsley), *soûl* (surfeited), *sourcil* (eyebrow), nor in *gentil*, except when it is followed by a word beginning with a vowel or an unaspirated *h*.

In certain words final *l* preceded by *i* assumes a liquid sound. With regard to the proper pronunciation of this liquid sound there is a difference of usage and of opinion. The simplest form of it consists in giving the *l* the value of very short *ye*, without, however, allowing it to form a separate syllable. The words that have this liquid sound of final *l* are: *avril*, pronounced *av ryee*, April (according to some authorities), *babil*, pronounced *babee-ye*, chatter; *cil*, pronounced *sea ye*, eyelash; *péril*, pronounced *perree ye*, peril.

The liquid sound of *l* occurs not only in certain words that have final *il*, but also the following terminations—*ille*, pronounced *ee ye* (except *ville*, town, and *mille*, thousand); *ail*, pronounced *aye*; *aille*, pronounced *aye*; *eil*, pronounced *aye*; *eille*, pronounced *āye*; *euil*, pronounced *ĕ ye*; *euille*, pronounced *ĕ-ye*; *œil*, pronounced *ĕ ye*; *ouille*, pronounced *ou-ye*; *uille*, pronounced *ou-ye*.

M and N.

Initial *M* is pronounced as in English, thus:

* See Liquid Sounds under L paragraph.

muse, pronounced *müze*, muse; *midi*, pronounced *mē dē*, midday.

Except in a few words, either Latin or of foreign origin, such as *item*, pronounced *ēetem*, item; *harem*, pronounced *arr-em*, harem, final *m*, together with the vowel preceding it, has a nasal sound.

This nasal sound arising from the letter *m* or *n* (not *mm* or *nn*), preceded by a vowel, should be pronounced without any *g*-sound. But as the nearest English equivalent always occurs with a final *g*, the phonetic explanation of the pronunciation of such words will in this course be accompanied by the *g* shown thus, ᵍ. For example: *champ*, pronounced *shawnᵍ*, field; *dans*, pronounced *dawnᵍ*, in, or into; *bon*, pronounced *bonᵍ*, good; *maison*, pronounced *may-zonᵍ*, house.

Nasal Sounds. 1. The nasal sounds are four in number: *an*, *in*, *on*, and *un*; but each of them represents various combinations. Thus:

2. The nasal sound of *an* is also that of *ant*, *and*, *anc*, *ang*, *am*, *amp*, *en*, *ent*, *em*, *emps*, and *aon*, and of *aen* in *Caen*.

3. The nasal sound of *in* is also that of *aim*, *ain*, *aint*, *eim*, *ein*, *eint*, *im*, *yn*, and *ym*.

4. The nasal sound of *on* is also that of *ont*, *ond*, and *om*.

5. The nasal sound of *un* is also that of *eun*, *unt*, and *um*.

6. All these combinations are, except in a very few words, pronounced with a nasal sound, when they are finals. As initials, or in the body of a word, they are nasal only when followed by a consonant other than *m* or *n*. Thus, *im* is nasal in *impossible* (*anᵍ poss-ēebl*).

7. *En* is nasal in *ennui* (*awnᵍ nwee*), and its derivatives.

M is silent in *automne*, pronounced *ō tŏn*, autumn, and also in *damner*, pronounced *dah ney*, to damn, together with the words derived from it.

Initial *n* is pronounced as in English, thus: *neuf*, pronounced *nŭf*, new; *ni*, pronounced *nēe*, nor. When followed by a vowel, it retains this sound in the body of a word, as in *anodin*, pronounced *an-o-danᵍ*, anodyne. *N* communicates the sound of *a* to the vowel *e* in *hennir*, pronounced *ay neer* (to neigh).

Except in *abdomen*, *amen*, *Eden*, and (according to some) *hymen*, pronounced *eemenn*, Hymen, final *n* gives the nasal sound to the syllable.

P.

Initial *P* is sounded very much as in English, but with a slighter opening of the lips, thus: *pas*, pronounced *pah*, step; *prune*, pronounced *prün*, plum; *poche*, pronounced *posh*, pocket. *Ph* has the value of *f*, as in English, thus: *phare*, pronounced *fahr*, lighthouse. It is sounded before *n* and *s* in words derived from the Greek, as: *pneumonie*, pronounced *pnŭ-mō-nēe*, pneumonia. It is usually silent before *t*, except in the initial syllable of words derived from the Greek, or from the Latin *septem*, thus: *septembre*. It is silent, however, in *baptême*, pronounced *bahteme*, baptism; in *compter*, pronounced *conᵍtey*, to count; *dompter*, pronounced *donᵍtey*, to tame; *sculpter*, pronounced *skültey*, to carve; and their derivatives; and in *exempt*, pronounced *exawnᵍ*, exempt; and *prompt*, pronounced *pronᵍ*, prompt. It is also sounded before *t* in *abrupt*, *inepte*, *adoption*, *captieux*, *reptile*, *accepté*, *rédempteur* (redeemer), and their derivatives. The meanings of the words are obvious.

Final *p* is usually silent, as in *camp* (camp), *champ* (field), *coup* (stroke), *drap* (cloth), *loup* (wolf), *galop* (gallop), *cep* (vine-stock), and also in *corps* (body) and *temps*, pronounced *tawnᵍ*, time. It is sounded in *cap* (cape). In *beaucoup*, pronounced *bō-kŏŏ*, much, and in *trop*, pronounced *tro*, it is sounded only before a word beginning with a vowel or mute *h*.

Q.

Except in *cinq*, pronounced *sanᵍk*, five, and *coq*, pronounced *kauk*, cock, the only two words in which it occurs as final, the letter *Q* is always followed by *u*. The combination *qu* has two different pronunciations, with regard to which no precise rules can be laid down. It may be said, in general terms, that *qu* is equal to *k* in words that belong to popular speech, as in *quoi*, pronounced *kwah*, what; *quitter*, pronounced *kee-tey*, to quit. In words commonly called of learned origin, *qu* has usually the sound of *kw* when it is followed by *a*, as in *aquatique*, pronounced *akwatēek*, and *equateur*.

In *cinq* the final *q* is sounded, except when that numeral multiplies a word beginning with a consonant or aspirated *h*, as *cinq francs*, pronounced *sanᵍ frawnᵍ*, five francs. In that case it is silent.

R.

The letter *R* is pronounced with a strong trill, produced by the vibration of the uvula, as in *rivage* (shore), *marine* (navy), *mercredi* (Wednesday).

Final *r* is sounded in the monosyllables *fer*, pronounced *ferr*, iron; *mer*, pronounced *merr*, sea; *cher*, pronounced *sherr*, dear; *or*, pronounced *or*, gold; *mur*, pronounced *mür*, wall; *fier*, pronounced *fēe-err*, proud; *hier*, pronounced *ēe-er*, yesterday; *sieur*, pronounced *sēe-er*, sir; but not in the compound *monsieur*. It is also sounded in final *ir*, as *plaisir*, in the dissyllables *amer*, pronounced *ahmerr*, bitter; *hiver*, pronounced *ēe verr*, winter; *enfer*, pronounced *awnᵍ-ferr*, hell; *éther*, pronounced *aterr*, ether; *cuiller*, pronounced *kwēe-yerr*, spoon; in a few Latin nouns and in some proper names.

Final *r* is silent in the combination *ier* in all polysyllables except those mentioned above, and in all infinitives in *er*.

S.

The letter *S* has two sounds—a sharp, hissing sound, as in the English word *sing*, and a softer *z*-sound, as in *fuse*.

Initial *s*, whether followed by a vowel or by a consonant, has the sharp sound, as in *sage*, pronounced *sahj*, wise; *scie*, pronounced *sēe*, saw.

In the body of a word *s* has the same sharp sound if it is either preceded or followed by another consonant, as in *lorsque*, pronounced *lawrsk*, when.

There is an exception to this in the case of words in which the Latin preposition *trans* occurs. Thus, *s* has the sound of *z* in *transiger* (to compromise), and in *transaction*.

The hissing sound is also produced by *ss* between two vowels, as in *passer*, pronounced *pah-sey*, to pass.

A single *s* between two vowels has the soft *z*-sound, as in *rose*, pronounced *rose*, rose; *misère*, pronounced *mëë-zairr*, misery; *maison*, pronounced *may-zon'*, house; *poison*, pronounced *pwah-zon'*, poison.

Final *s* is usually silent, as in *dans*, pronounced *dawn'*, in; *sous*, pronounced *soo*, under; *poids*, pronounced *pwa*, weight.

Final *s* is sounded in *tous* (pronoun), but not in *tous* (adjective), meaning "all."

When *plus*, pronounced *plü*, more, helps to form comparatives and superlatives, the final *s* is silent. It is also silent in *ne . . plus* no longer. It is sounded in *plus* = more, in *pas plus*, in *de plus en plus*, and in *plus-que-parfait*.

Final *s* is silent in *Jésus*.

T.

The sound of *T* is similar to that of the same letter in English, but rather softer, owing to the absence of the slight aspiration that generally follows it in English. Initial *t* always has the same value, as in *table* (*tahbl*), table. In the body of a word it retains this sound when it is followed by a consonant or any vowel but *i*, as in *entrain*, pronounced *awn'-train'*, dash; *entamer*, pronounced *awn'-tammey*, to broach.

In *ti*, the *t* retains its own pronunciation (1) when preceded by *s* or *x*, as in *bastion*, pronounced *ba-steeon'*, bastion; *mixtion*, pronounced *meex-teeon'*, mixture; (2) when followed by *tié* or *tier*, as substantive endings, thus: *amitié*, pronounced *amee-tee-ey*, friendship; *entier*, pronounced *awn'-tee-ey*, entire; (3) when followed by *e* mute, as in *partie*, *modestie*. The exceptions to this are a few nouns, of which *prophétie*, pronounced *profey-sëe*, is an example, and all nouns in *atie*, as *democratie* (democracy), in which *ti* becomes *ci* in pronunciation; (4) when followed by *en* or *enne*, as in *tenir*, to hold.

Final *t* is usually silent, but is sounded in *abject*, pronounced *abject*, abject; *brut*, pronounced *brütt*, coarse.

T final is silent in *vingt* (except when followed by a noun beginning with a vowel or mute *h*), in *quatre-vingts* (80) and all the numbers from 80 to 99. It is sounded in *vingt et un* (21) and all the remaining numbers up to 29.

It is also silent in *sept*, pronounced *set*, seven; and *huit*, pronounced *wëët*, eight, when these numerals multiply a number beginning with a consonant or aspirated *h*.

Final *t* is pronounced in *Christ*, and Protestants usually retain this pronunciation in *Jésus-Christ*. Catholics seem to prefer a pronunciation in which both *s* and *t* are silent, and say *Jésu-Chri*.

Th, whether initial, medial, or final, is pronounced like *t*, as in *thé* (tea), *méthode* (method), *zénith* (zenith). It is wholly silent in *isthme* (isthmus).

V.

The letter *V* is pronounced as in English, thus: *vivre*, pronounced *vëëvrr* (to live). It is never final.

W.

W never occurs except in words of foreign origin. It usually has the sound of *V*, but is sometimes pronounced like *oo* in English words, such as *whig* and *whist*.

X.

Initial *X* occurs in a small number of purely scientific terms derived from the Greek, and also in a few proper nouns of foreign—chiefly Greek—origin.

In the body of a word, *x* has approximately the same value as in English.

X has the value of *z* in *deuxième* (second), *dixième* (tenth), *sixième* (sixth).

In *soixante* (sixty), with its derivatives, and in *Bruxelles*, *x* has the sharp sound of *ss*.

Final *x* is usually silent, thus: *paix*, pronounced *pey* (peace), *prix*, pronounced *pree* (price).

It has the value of *ss* in *six* (six) and *dix* (ten), except when those numerals multiply a noun beginning with a consonant or an aspirated *h*, as *six heros*, *dix mois*. In that case it is silent.

When carried on to the next word, final *x* takes a *z* sound, thus: *deux hommes*, *six ans*, become *de-zom*, *see-zan'*.

Z.

Z is sounded as in English: *zone*, *gazon* (turf), *douze* (twelve).

Final *z* is silent in *nez* and *chez*. It takes the sharp sound of *s* in *Metz*.

A liquid sound peculiar to the French language is formed by the combination of *gn* in the body of a word. It approximates the *ny* of *Bunyan* or the *ni* of *union*. Thus, as regards this sound, there is a similarity between *compagnon* and *mignon* and their English equivalents *companion* and *minion*. When *gn* occurs in final *gne*, as in *signe* (sign), its sound may be approximated by giving it the value of a very slight and slurred *nye*: *seen-ye*.

To be continued

Note. A first course in German appears in Part II of the Self-Educator

ELECTRICITY

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CONDUCTED BY

Professor SILVANUS P. THOMPSON, Doctor of Science; Fellow of the Royal Society; Past President of the Institution of Electrical Engineers; Principal of the City and Guilds Technical College, Finsbury; and

D. H. KENNEDY, of the Post Office Telegraphs and Telephones Department; Associate Member of the Institute of Electrical Engineers.

THE PLACE OF ELECTRICITY IN THE MODERN WORLD

By Professor Silvanus P. Thompson

AFTER the Stone Age, the Bronze Age, and the Iron Age, by which names learned men distinguish the steps of civilisation in pre historic time, come in rapid succession the Age of Steam and the Age of Electricity.

Let anyone try to picture to himself the quiet, slow-moving world in which our grandfathers and great-grandfathers lived, before the advent of the locomotive or the steamboat, before the telegraph or the telephone, before the electric light or the electric motor. To travel by coach from London to York required four days. To send a letter from London to Paris required at least a week. To sail from London to New York needed a month. Gas lighting made its appearance in the streets of our cities early in the nineteenth century; but, for the rest, the tallow candle and the dim colza oil lamp were the means of domestic lighting. The factories, thanks mainly to James Watt, had their steam-engines, of primitive type.

The Coming of the Steam Engine. With the advent of the steam-engine grew up our factory system, where men and women were herded together in dark factories, because steam power on any small scale for the individual worker was quite uneconomical. With the steam-engine as a pumping agent mining could progress, and town-supplies of water became a possibility. Not until the development of the locomotive in the middle of the nineteenth century were towns brought into reasonable communication with one another; nor until the marine engine had been developed could interchange of news and of products and manufactures between one country and another come into active existence. With the introduction of steam-engines began the taste, the fashion, and the general use of travel, the growth of markets dependent upon the rapid transportation of goods, and the establishment of national and international postage. All this vast development, the beginning of which our grandfathers witnessed, has gone on until our time, and still goes on. But its progress has been vastly hastened, and its extension widened by that still more modern and more scientific agency—electricity.

A Revolution of Our Own Time. Quite recent is the introduction of electricity into the service of man. While the electric telegraph in Great Britain dates from about 1840, the submarine cable from 1854, and the electric bell from about 1855, the commercial introduction of the telephone from about 1878, that of the electric light dates from about 1878, the public supply of electricity from about 1883, the industrial use of electric motors from about 1886, electric tramcars from 1883, electric railways from 1892, and wireless telegraphy, though its inception was in 1894, began to be used only in 1899.

The vast development of electric work to-day, with its thousand applications, has been the product of many minds, the fruit of the labours of comparatively few pioneers. The salient discoveries can be stated very briefly. Until the end of the eighteenth century, the only electrical facts which had been discovered or explored were those relating to the production by friction of electric charges, which could indeed be made to give shocks or sparks, but which had no commercial applications.

It was true that Benjamin Franklin had identified lightning as an electric discharge, and had invented the lightning-rod for the protection of property from thunderstorms. But so long as the artificial production of electric effects depended upon the rubbing of amber with flannel, or of glass with silk, this primitive excitation of stationary electric charges was barren of useful applications. It was not even

established that electricity had any connection with magnetism, though it was suspected that there were relations between the two agencies.

The Electric Current. With 1800 came the invention by Alessandro Volta of the voltaic pile, followed by its improved form, the voltaic *cell*. For the first time science was provided with a steady and manageable source, from which a quiet, continuous flow of electricity as a *current* could be procured. These currents could be guided along metallic wires, usually of copper, constituting an electric circuit, which conveyed the current from its starting-point in the cell—or, in more powerful combinations, from a whole battery of cells—to any required place, and led it back by a return path to the starting-point.

The properties of the electric current were quickly investigated. Metals and many liquids were found to conduct it: glass, marble, wax, oil, and air were found to stop its passage, acting as non-conductors or insulators. It was found to heat thin wires. In 1802 Humphrey Davy discovered the *arc* or electric flame produced when the current passes between the tips of two sticks of carbon. He also investigated the power of the electric current to cause chemical decomposition in passing through salt-solutions, through fused alkalis, or through acids. In 1820 Oersted discovered that the electric current could cause a deflection of a compass needle placed near the wire that carried the current, and so opened the new domain of electro-magnetism.

First Electric Motor. This was followed by the invention of the galvanometer, the instrument by which currents are detected and measured. In 1822 Faraday produced the first electric *motor*, in which a magnet was caused to rotate around a current, or the wire carrying the current was caused to rotate around a magnet. In 1825 William Sturgeon invented the soft-iron *electro-magnet*, an instrument of vast importance in all the modern engineering applications. Down to that time the only known magnets were either natural lode-stones or else pieces of steel (bars, needles, or horseshoes in form), to which magnetism was imparted once for all. Their magnetism was in this sense permanent, not capable of being turned off or on at will, not capable of being controlled from a distance. Sturgeon found that by winding a coil of wire around a rod or horseshoe of soft iron, and then connecting the coil by wires to an electric circuit which conveyed electric currents from a battery, so that the electric current circulated around the iron, the iron core became a powerful magnet, but continued so only so long as the electric current was permitted to circulate. On stopping the current, which could be done by opening the circuit at any point—which might be far away—the soft iron core ceased to attract. On re-closing the circuit the circulation of current began again, and the iron core again became magnetic, and exerted its pull on a neighbouring iron armature.

Here, then, for the first time in history, was man provided with a magnet that could be controlled and operated from any distance. The electromagnet is the beginning of all electrical engineering. An electromagnet is an essential feature in every modern telegraphic instrument, in every sounder, recorder, and relay, in every telephone, in every electric bell, in every motor, in every dynamo, in every electrically-operated railway signal. Millions of electromagnets are constructed every year; but the essential principle of them all goes back to William Sturgeon's electromagnet of 1825.

Generation and Transformation. In 1831 Michael Faraday made two discoveries of equally fundamental importance, when he established the principles of the *mechanical generation* of electric currents and of their *transformation*. Down to that date the only methods known for generating electric currents had been either the chemical method used in the voltaic cell, or the less useful method of the thermopile (discovered in 1822 by August Seebeck), in which heat applied to the junctions of metallic bars set up feeble electric action. But Faraday took a step far in advance when, after many failures and a deliberate and determined scientific search, he discovered a mechanical process for generating currents by the moving of magnets near coils of copper wire. Of this discovery, and of its far-reaching consequence—the invention of the dynamo—there is much to be said when we come to consider the dynamo. Suffice it here to say that without this transcendent discovery of the mechanical method there would have been none of the larger practical applications of electricity to engineering work.

Even as it was, no practical application of this method was adopted in commerce for a number of years. It is true that primitive kinds of dynamos, under the name of magneto-electric machines, were made for laboratory purposes. Faraday himself made such in 1831, Pixii in Paris and Saxton in London quickly followed with other forms. In 1841 Woolrich, of Birmingham, devised a machine capable of being driven by a steam engine, and furnished currents for electroplating; and Sinsteden, in 1851, devised the method of using a small magneto-electric machine to excite the magnets of a larger one, thus obtaining mechanically currents far exceeding those of the largest batteries previously known. He described experiments on the fusing of copper and iron wires, and made experiments on glow-lamps of platinum wire.

Era of Electric Lighting. From 1857 to 1865 inventors were busy perfecting magneto-electric machines for lighthouse lighting; while Wheatstone, Siemens, Varley, Pacinotti, and Wilde introduced various improvements in respect of greater continuity of current and in modes of exciting the magnetism of the magnets. In the early seventies a special pattern of dynamo by Gramme, of Paris, having as the revolving armature a continuous *ring-coil*, came into commercial use and quickly won its way. The era of electric lighting by arc lamps followed in the years from 1874 to 1884, succeeded by the introduction of the glow-lamp.

Amongst Faraday's inventions of 1831 was that of the induction coil or transformer, a

device by which an electric current flowing in a coil of wire induces a current to flow in a neighbouring coil of wire, the action being dependent upon the variations of strength of the primary current [see a later Chapter in this section on TRANSFORMERS].

The first application of this discovery was the spark-coil, an apparatus for obtaining bright long sparks by induction from a mere current from a few voltaic cells. The later application in the modern alternate current transformer for changing high pressure currents into low-pressure currents, or *vice versa*, came into commercial importance only about 1883, when alternate current generators had been put upon the market for the purpose of electric lighting. Without the transformer there would have been none of the great schemes for the electric transmission of power, or the utilisation of the energy of waterfalls, for such transmission of electric energy would be wholly uneconomical unless the current could be conveyed at very high pressures, and high pressure currents cannot be used for lighting or tramway work unless they are transformed down to a suitable low pressure. All this we shall see in due course [see Chapter on TRANSMISSIONS OF POWER].

Systems of Transmission. After alternating electric currents had thus been introduced, there came the invention by Ferraris in 1885, and by Tesla in 1888, of the combination of two, three, or more separate alternating currents in different *phases*, to work alternate current motors, and so arose the two-phase and three-phase systems of transmission—the latter predominating to-day in all the great schemes of electric engineering.

With batteries for the generation chemically of weak currents, the telegraph, the telephone, and the electric bell received their natural development. With dynamos for the mechanical generation—by steam engines, or water power, or gas engines—of continuous currents, there followed the application to electrotyping, electroplating, electro-gilding, and nickel-plating, as well as the supply of electricity to arc lamps for public lighting and glow-lamps for interior illumination, and to the propulsion of tramcars and electric locomotives. With the alternator for the mechanical generation—by power—of alternating currents, aided by the use of the transformer, came the utilisation of waterfalls and the transmission of electric power on the large scale from generating centres or power houses, the currents being transmitted to suitable distributing centres and there transformed down or converted into continuous current as required by the various consumers. The driving of factories by electric motors; the use of electric furnaces for smelting and the manufacture of alloys and of new chemicals; the propulsion of heavy trains by electric motors—all these became possible only by the developments just recited, and these all originate with the scientific researches of Michael Faraday.

A Recent Revolution. How great has been all this recent development a few statistics will reveal. Before 1880 there was not in Great Britain a single house electrically lighted, nor a single supply-station erected for the public distribution of electricity. At the end of 1895 there were 38 public companies for electric supply, with a total capital of £5,831,000, and 33 municipal undertakings with an authorised capital of £1,900,000. There were at that date about 2,000,000 of glow-lamps in use in Great Britain, and about 18,000,000 *units* of electric energy were supplied in that year to the public, the average working cost per unit being over fourpence. By New Year's Day in 1905 there were 183 public companies, with a total capital of over £30,000,000; 262 municipal undertakings, with authorised capital of £31,600,000. Nearly 20,000,000 glow-lamps were connected up, and over 448,000,000 of units of electric energy per annum were being sold with an average working cost reduced to 2·3 pence. In electric tramways, of which the first two were opened in 1883, there were in 1896 only sixteen companies, with a capital of £6,000,000. In January, 1905, these had grown to 159 companies, with a capital of £79,000,000, while 115 municipal bodies had spent £27,870,000 on tramways. The earliest of electric tube railways was the City and South London, opened in 1890, which has now 12½ miles of track. There are now in London alone 193 miles of track in electric operation, and 64 miles more are either under construction or in process of conversion from steam propulsion. In the provinces there are 146 miles of electric railway in operation, and over 100 more authorised or in process of conversion.

A Hundred Thousand Horse-Power. The number of electric bells sold in Great Britain alone averages something like a million a year. The total mileage of telegraph wires which, when taken over in 1870 by the State, was much under 100,000, is now over 300,000 miles. The number of telegraphic messages sent during the year 1904 was nearly 90,000,000, while the capital value of the telegraphs of Great Britain is estimated to be £36,000,000, and that of the telephones £13,200,000. Great power-houses for the generation and supply of electric energy to be transmitted to factories and workshops have been erected in a number of industrial centres, at Newcastle, in South Wales, in the Midlands, in the Clyde Valley, in North London, in Yorkshire, and in Lancashire, with others in progress. These together represent an output of over 100,000 horse-power, and a capital expenditure in total of £900,000. The invention by Parsons of the steam-turbine has given a great impetus to these latest developments.

It will thus be seen to what an immense commercial importance the electrical industry has grown. Without reckoning in any submarine cables or any manufacturing concerns, the total capital expended upon the electrical undertakings enumerated above may be approximately stated at over £220,000,000. If we put down the capital of the submarine cable companies at £25,000,000, and that of the electrical manufacturing undertakings in Great

each of these containing at least two sorts of atom. A substance is known as *complex* when its molecules are composed of a large number of atoms. Protoplasm is undoubtedly complex in this sense, though it must not be supposed that it is necessarily a substance of definite chemical composition, as are water, starch, and cane-sugar. Very complex substances are eminently unstable, and when protoplasm dies it no doubt "falls to pieces," so to speak.

The Chemistry of Life. As we can only subject dead protoplasm to chemical analysis, a great difficulty presents itself when attempts are made to determine its actual chemical nature. But we know that its nearest allies are to be found in what are termed *proteids* or *albuminoids*, of which white-of-egg is a typical example. Yet even these are so complicated in nature that so far we know little more than their percentage composition, and till they are thoroughly understood the true nature of living matter is far to seek. Chemistry, however, has made such huge strides in the past that we are justified in expecting further enlightenment in the immediate future.

At no very distant date a sharp distinction was drawn between Inorganic and Organic Chemistry, the latter dealing with substances which it was supposed could only be formed by the vital activity of plants or animals. But as since then some of these very substances, *e.g.* grape-sugar and indigo, have been actually built up or synthesized in the laboratory, the same may ultimately prove possible for proteids. Some sanguine spirits even anticipate that living substance will some day be manufactured. Should this dream of the old alchemists ever be realized, we shall be justified in considering life a matter of chemistry and physics; but till then it is better to remain in an attitude of suspended judgment.

A Cycle of Changes. Living matter is further distinguished from non-living by the fact that it passes through a *cycle of changes*, which terminate in death with resolution into non-living substances. It is, indeed, possible that death is not an absolute necessity in the case of certain of the lowest animals, as we shall see in the sequel. But the statement is broadly, if not universally, true. During the life of an organism there is a constant breaking down of the complex substance of the body, associated with an equally constant up-building, whereby waste is compensated, growth rendered possible, and the production of new individuals made practicable. Without such chemical breaking-down the energy necessary for carrying on the various acts of life would not be available. In ourselves, for example, movement, the production of digestive juices, sensations, and even thought, are all associated with such disintegration. There is a constant ebb and flow. The body of an organism retains a constant form with changing substance, like an eddy in a stream. It may be added too that the form is typically bounded by curves.

Turning to non-living matter, we find that these cyclical changes are not manifested. A piece of rock-crystal, for instance, may retain its properties unchanged for an indefinite period. Under certain circumstances, indeed, it may grow, as do crystals of sugar-candy on a string, but the growth takes place by the addition of layers to the exterior, the interior remaining unaltered. And when non-living matter has a definite shape, as in crystals, it is bounded by sharp edges, and, as a rule, by flat surfaces. Some crystals, as those of diamond, may, it is true, possess curved faces, but the sharp edges are always there.

The Kingdom of Biology. The distinctions between higher plants and higher animals are sufficiently obvious, though both are essentially composed of protoplasm; but as we descend the scale the differences become less striking, until among the lowest forms of life it is not always possible to be absolutely sure in a given case whether we are dealing with a plant or an animal. We may, in fact, compare the two great kingdoms of the organic world to the two strokes in a V, which are distinct above, but unite together below, while the letter Y may be taken to represent both kingdoms, together with the common stock from which they have probably been derived. The actual points of difference are best reserved till we know a little more about plants and animals.

So much is known about the myriads of organisms which either exist or have existed, that plants and animals are commonly dealt with separately by the two sister sciences of Botany (Greek, *botanē*, a plant), and Zoology (Greek, *zōon*, an animal; *logos*, a discourse), which treat respectively of plants and animals, though it must not be forgotten that these are not marked off from one another with absolute distinctness, besides which they are inter-related in so complex a fashion that many problems can only be adequately solved by the co-operation of botanists and zoologists.

Either Botany or Zoology is susceptible of division into departments, though here, again, there is necessarily more or less overlapping. The first of these departments is Classification.

Classification. When dealing with a multitude of objects of any kind, it is an obvious matter of convenience to divide them into groups, according to their resemblances and differences, in other words to *classify* them. Postage stamps, coins, books, pictures, or what not, all require classification if they are to be studied intelligently, and the proprietor of every shop is aware of the necessity of arranging his wares according to some definite plan, so that customers can be served with promptitude and ease.

In similar wise naturalists have long been accustomed to adopt some kind of classification of plants and animals, and one of the most notable advances in this direction was made by the great Swedish botanist Linnæus during the eighteenth century, in his "Systema Naturæ." In his, as in all subsequent systems, the different kinds of plant or animal are termed *species*, though the exact definition of a species is an

exceedingly difficult matter, as we shall later on have occasion to learn. Species are aggregated into larger groups or *genera*, these into still larger assemblages, and so on, until at last we reach the *sub-kingdoms* of Plants and Animals, which together make up the *kingdom of Living Things or Organisms*. The resemblances between members of the same species are so close that all *of them can be readily believed to have sprung from the same stock. But as we go to larger and larger groups the resemblances are fewer and of more general character, while the differences are broader and more marked.*

Scientific Names. We also owe to Linnæus the convenient system of *binomial nomenclature*, by which a double "scientific name" is given to every animal or plant. There are, for instance—amongst others—three common British kinds or species of Buttercup, known to botanists as *Ranunculus bulbosus*, *Ranunculus acris*, and *Ranunculus repens*. In each case the second is the specific name, and the first the generic name, these bearing much the same relation to one another as the Christian and surnames of a man, except that the order is reversed, as in many official lists of human beings. The individuals of the species *bulbosus* resemble one another even in minute details, as do those of *acris* or those of *repens*. And although the members of the three species are in some respects different, they agree in most particulars, so that it is justifiable to place all three of them—together with a number of other species—in the same group or genus—*Ranunculus*—of the next higher order.

Such scientific names are mostly derived from Latin or Greek, or both, these languages being the common property of all civilized nations, and they possess the great advantage that they can be used so as to be universally intelligible. English, German, Russian, and Italian botanists alike understand what plant is signified by the name *Ranunculus bulbosus*, but common or popular names vary so much that endless confusion would be caused if they were employed in scientific works. To absolutely guard against misconception, however, it is necessary to indicate by initials the authority who gave the particular specific name, as the same plant or animal has sometimes received more than one appellation, while on the other hand the same verbal label has been attached to more than one plant or animal, both possibilities being the result of imperfect knowledge of work already done. The complete name of the plant in question is *Ranunculus bulbosus* L., where the initial stands for Linnæus.

Natural Affinities. The older attempts at classification were generally more or less artificial, in that they were often based on superficial characters, which might or might not indicate close relationship. A good example of this is afforded by the old group of backboned animals to which the name of *Quadrupeds* was given, embracing all backboned animals with four legs, tortoises and toads, as well as cows and cats. But the two former are cold-blooded animals devoid of hair, while the other two are warm-blooded, covered with hair, and suckle their young. It may be added that the limbless snake is undoubtedly a relative of the tortoise, and that the whale, which possesses no hind legs, belongs to the same great group as the cow and cat. Anomalies like this were gradually realized, and in the early part of last century "natural" classifications came into vogue, which attempted to group organisms in a less arbitrary way. And it was ultimately perceived that the mutual affinities of groups were best expressed by arranging them in a sort of classificatory tree.

Why classification should assume a tree-like form was not fully realised till 1858, when Darwin and Wallace brought forward their theory of Evolution, the "Origin of Species" of the former appearing the following year. The idea of evolution—of the origin, that is to say, of existing species from pre-existing ones, as against the doctrine of the *special creation* of each and all—was no new thing, and had at various times been brought forward from the days of the old Greek philosophers downwards. Suggestions had even been made as to the way in which it might possibly have come about. But it was reserved for Darwin and Wallace to marshal so large an amount of evidence with such irresistible force that the *fact* of evolution is now no longer seriously questioned by competent authorities. At the same time these two scientists propounded an invaluable theory as to the *means* by which evolution has been effected.

The Influence of "Darwinism." Since 1858 "Darwinism," to use a widely current term, has revolutionized Biology, and exerted a profound influence upon many other branches of learning. Among other things our conceptions of classification as applied to organisms have been greatly modified. For if organisms are actually all of common descent, a new meaning attaches to such words as *affinities* and *relationships*, formerly employed in a vague and indefinite way. The classificatory tree is, in fact, a *genealogical* one, and the more nearly it expresses direct and collateral blood-relationships the more nearly does it approximate to what practically all modern biologists believe to be the truth. The larger branches of the classificatory tree correspond to the larger groups of the organic kingdom and the smaller branches to the subordinate groups, while the final twigs may be taken to correspond to species, and the leaves which these bear to individual plants and animals.

Morphology. *Morphology* (Greek, *morphé*, form; *lógos*, a discourse) is the second subdivision of Biology. Vegetable Morphology is concerned with the form and structure of plants, while the sister department of Animal Morphology has to do with the form and structure of animals. And here a further subdivision is possible, for we have *Anatomy*, which treats of the more obvious facts of structure, and *Histology* (Greek, *histós*, a texture; *lógos*), which brings the microscope to bear upon

minuter anatomical details. Morphologists are not content with merely observing and recording facts, but in all cases attempt to find out *why* things are as they are. To many such questions reasonable answers have already been found, as we shall soon see; but there are innumerable problems which still await solution.

Physiology. The third division of Biology is that of *Physiology* (Greek, *phŭsis*, nature; *logos*, a discourse). Here a distinction is drawn between Vegetable and Animal Physiology, which deal respectively with the uses or functions of the various parts of plants and animals. While the morphologist is primarily concerned with the organic machine at rest, the physiologist studies its actual working. It is, of course, sufficiently obvious that function cannot be studied without some knowledge of structure, while mere anatomy would prove very uninteresting and largely unintelligible if considered absolutely without reference to the uses of the parts of the body.

Development. Development, or *Embryology*, the fourth division of Biology, is concerned with the evolution of the individual, from its first inception up to the adult condition, and is in reality the morphology and physiology of immature organisms or embryos

Applied Biology. The fifth division, *Applied Biology*, has to do with the useful application of biological knowledge to human industries, and naturally falls into the two departments of *Applied Botany* and *Applied Zoology*, both of which are of fundamental importance for Medicine and Agriculture. Applied Botany, again, has a bearing upon industries which are concerned with the employment of vegetable fibre and woods of various kinds, while Applied Zoology is of primary value for the intelligent conduct and proper development of Fisheries, etc

Distribution. The *Distribution* of plants and animals constitutes still another large branch of Biology, and one, too, which is of absorbing interest. If we take either Plant Distribution or Animal Distribution, we shall find that it embraces two closely-related subdivisions, *i.e.* Distribution in Space, or Geographical Distribution, and Distribution in Time.

Geographical Distribution is concerned with facts and theories as to the way in which existing plants and animals are disposed with reference to the surface of the globe. The plants of a given area constitute its *flora*, the animals its *fauna*, and the nature of these assemblages in a given case does not altogether depend upon climate, as commonly supposed. The marked peculiarities of the fauna and flora of Australia; the fact that horses and camels are indigenous only to the Old World, while armadilloes and humming-birds are limited to the New; the extraordinary character of many fishes inhabiting the abysses of the ocean; these and many other matters of the greatest interest present themselves to the student of geographical distribution

Distribution in Time. The solid framework of the globe is largely made up of layers or *strata*, composed of rocks such as sandstone, slate, and limestone, which once existed as accumulations of sand, mud, or the like, on the floor of the sea or of inland bodies of water, and have since been consolidated and upheaved to make part of the dry land. As is fully explained in the section on GEOLOGY, it has been found possible to arrange these strata in chronological sequence, largely by application of the simple principle that when several such layers rest one upon the other the undermost are necessarily the oldest and the uppermost the youngest. Rocks of the kind commonly contain *fossils*, *i.e.* the remains of organisms which formerly existed, or proofs, such as footprints, of the existence of such organisms. We are thus enabled to acquire a large, though necessarily imperfect, knowledge of the ancient floras and faunas of the globe for a period of many million years. Going back in time, we find that formerly existing plants and animals become less and less like those which now exist, while speaking broadly they are of lower and lower kind. The evidence afforded by the "record of the rocks" is conclusive as to the fact of evolution, and the genealogies of some groups of organisms have now been worked out in considerable detail

Higher Problems of Biology. The seventh great subdivision of the subject, *Philosophic* or *Theoretical Biology*, has for its province the consideration of the higher problems which present themselves to the student of Biology, and the construction of theories by which the existing order of things receives intelligent and intelligible explanation. Its data are derived from Botany and Zoology alike

While either Botany or Zoology is divisible into all these subordinate divisions, the latter subject merges into studies of still higher kind. Among these may be enumerated *Anthropology* (Greek, *anthropos*, man; *logos*, a discourse), dealing with mankind; *Psychology* (Greek, *psuche*, soul or mind; *logos*), treating of mind; and *Sociology*, which is the study of human communities. The influence of the Theory of Evolution has made itself felt far beyond even these limits, and has largely modified our attitude towards many other departments of learning, among which Language, History and Theology may be included.

We are now in a position to understand what is meant by NATURAL HISTORY, the subject of this course. It is not so much a subdivision of Biology as a biological attitude. The naturalist studies plants and animals so far as possible in their natural surroundings, or in such a modification of these as may be presented by a vivarium or an aquarium. Although he resorts, when necessary, to the resources of the laboratory or museum, his observations and experiments are made by preference on organisms "at home." He may collect plants or animals with some definite scientific end in view, but does not accumulate dried flowers, birds' eggs, butterflies, or shells, merely for the sake of collecting, as so many persons do

The Aim of Natural History. Natural History aims at determining the relations between organisms and their surroundings or environments, and therefore deals with habits and their meaning. The special names of *Bionomics* (Greek, *bios*, life; *logŏs*, a discourse) or *Ecology* (Greek *oikos*, home; *logŏs*), are often applied to Natural History as used in this sense. Every species is more or less well adapted to its environment, and the study of adaptations offers an inexhaustible field for observation and experiment. The shapes of leaves, the colour and structure of flowers, the varied hues of insects and birds, the structure of a spider's foot or a bat's wing; these, and things like these, all have some adaptational meaning. And our enjoyment of Nature is vastly heightened if we see with understanding eyes.

A competent naturalist must possess a working knowledge of Classification, or he will be incapable of understanding the relation of various groups of organisms to one another. The buttercup, marsh marigold, columbine, larkspur, and monk's hood, for example, are each and all interesting plants, but the interest is increased when we know that they are nearly related, and that the marked differences between them are variations of a common plan, brought about by adaptation to different surroundings. And the same remark may be made of such an assemblage of animals as the rabbit, rat, squirrel, guinea pig, and porcupine.

The naturalist must also be more or less of a morphologist and physiologist. The flight of an insect or a bird, for instance, cannot be properly studied without a knowledge of both structure and function, and an acquaintance with both is equally necessary if he wishes to intelligently understand how a bee rifles flowers of their nectar, or how a pitcher plant catches its insect victims.

The Study of Life-histories. Development also largely falls within the purview of Natural History. It is true that the microscopic details of the processes whereby a full-grown plant is evolved from a microscopic germ, or a frog from a relatively small egg, are the special province of the laboratory worker. But the naturalist can observe the germination of the seed, and the gradual metamorphosis of the tadpole into the frog, or the caterpillar into the butterfly. It may be safely asserted that the study of such "life histories" is among the most fascinating, if not the most fascinating branch of the subject.

With Applied Biology, as such, the naturalist is not necessarily concerned. But should he desire to do work which is useful as well as interesting, there is abundant scope for his energies. The name is legion of the insects and lower plants which infest our cultivated crops and sadly diminish the earnings of the farmer, while our knowledge of them is very imperfect. To study the habits, and carefully work out the life-histories of such forms is the first step towards combating their ravages. And work of the kind requires nothing but patience, conjoined with the power of accurate and careful observation.

Most work on Distribution is beyond the powers and opportunities of the average amateur naturalist. But the careful study of the flora or fauna of a district, or of a particular group of plants or animals, may furnish valuable material for the advancement of this branch of biology. Much remains to be known, for instance, of the distribution of British land-snails and land-slugs. Good local field work can still be done in Britain with regard to Distribution in Time, for the careful collection of fossils from cliffs or quarries is calculated to advance our knowledge. But it is not enough to pick them up from heaps of rubbish. The exact layer or stratum to which they belong must be carefully determined, or energy will be expended almost in vain.

It may be added that the naturalist ought to know the broad outlines of Philosophical Biology, so far as evolutionary principles are concerned. Allusion will elsewhere be made to experiments on heredity which can be carried out by anyone of average intelligence.

It is hardly necessary to insist upon the importance of Natural History as a branch of study which should form part of every education aspiring to be termed "liberal." To take an intelligent interest in the plants and animals which everywhere obtrude themselves upon our notice, is to possess a perennial and inexhaustible source of happiness, to say nothing of the practical value of trained powers of observation and reasoning. And such study goes far to satisfy the craving for the knowledge of "how" and "why" for knowledge sake, which is among the most deeply-implanted instincts of the human mind. It is much to be hoped that the attempt which is now being made to introduce Natural History — under the name of "Nature Study" — into schools will meet with permanent success and yield abundant fruit.

To be continued

BUILDING

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Professor R. ELSEY SMITH, Professor of Architecture and Building Construction at King's College, University of London; Fellow of the Royal Institute of British Architects; Examiner in Architecture to the Board of Education

Professor HENRY ROBINSON, Emeritus Professor of Civil Engineering at King's College, University of London; Member of the Institute of Civil Engineers; and other authorities

MAIN CONDITIONS GOVERNING BUILDING CONSTRUCTION

By Professor R. Elsey Smith

An intimate acquaintance with the various materials used in construction, their nature, properties, defects, and appearance, is an essential qualification for any one who in these days aspires to be connected with either the design or erection of buildings.

It is of great importance to be able to distinguish between good, indifferent and bad qualities of the same material, and to realise that for certain classes of work the materials used must be varied according to the governing conditions, and to feel sure, in specifying materials, that the qualities described are such as can be readily obtained.

Special articles in this work deal with the nature and chemical and physical properties of the various materials used in the building trades, but the student must neglect no opportunities of examining materials in use in actual building, paying where possible repeated visits to works in progress, and noting the result of the use of certain materials. He should endeavour, also, to ascertain the conditions determining the selection of material for a particular purpose in a particular locality.

Materials and Methods. It is true, in these days, that almost any material may be brought to almost any spot; but the cost of conveyance and cartage may form a very heavy item in the value of such goods when delivered. Though the conditions regulating the use of materials give a wider scope in this respect than they did, say, a hundred years ago, it is often important, where building with due regard to economy is to be observed, to be able to examine and select local materials, and to determine to what extent they may be relied upon. Beyond the mere utility, there is also, in many cases, a great pleasure and charm in the use of such materials; a certain local character may often be given to the appearance of a building by their adoption [1].

In dealing with the various trades, the materials in ordinary use will be referred to briefly, the special characteristics necessary for a proper specification will be emphasised, but for more complete accounts of the various materials, the student should consult the special section on Materials and Structures.

Of no less importance than a knowledge of the materials is a proper acquaintance with the methods employed, of so combining them as to form integral parts of a building, and of the completed building itself. This implies an acquaintance with the various processes of very many trades; though no one can expect to become a completely equipped workman in all, it is possible to acquire such knowledge of them as to be able to distinguish excellent and moderate workmanship from indifferent and poor work. Such knowledge is necessary in order to design work that others can execute, or to superintend the work of others, as well as in carrying out the work itself.

Changed Conditions. The conditions of to-day, in relation to building as well as in many other directions, are totally different from those in force in this and other countries for several centuries, during which the magnificent cathedrals and the vast monastic establishments and important public and private works were erected.

Throughout this period the workmen were associated in guilds, according to their trades; they were instructed in their various handicrafts, and worked in association with their fellow-craftsmen, moving often from place to place as work was completed, in considerable bands. The work was arranged for by the master-builder, and the drawing or design, from which even an important building was erected, was comparatively simple and elementary. At this period, the style in which work was executed, though it slowly changed and developed, was at any one period fairly sharply defined, and, subject to the

effect of local conditions, was in general use throughout the country; all the workmen were instructed in the manner of work at the time in vogue, but at the same time much scope was left for the exercise of originality by the individual workman.

Variety in Detail. The result of this system is seen in the work of the mason and carpenter, and, in particular, in the carved enrichments which were such an important feature in the scheme of mediaeval craftsmanship. In any portion of a great church or cathedral, erected at one and the same period, a general similarity of the style of the carved enrichments will be observed; but a closer examination will generally reveal an almost infinite variety in the details of the work. The ideas of each individual craftsman were allowed full play, with the result that in a perfectly harmonious building there is still a splendid variety in the minor parts and great interest is given to the detail.

The conditions of social life and of work are very different in our days. The functions of the designer, or architect, and the actual constructor, have become more completely separated, and for many classes of work entirely so. There is, moreover, at this present time no single style prevalent and recognised as in general use in this country. One result of this is that a workman, while engaged upon one structure, may be required to execute a piece of work in the manner of one of the Gothic periods, and directly afterwards may be transferred to work of a Renaissance character.

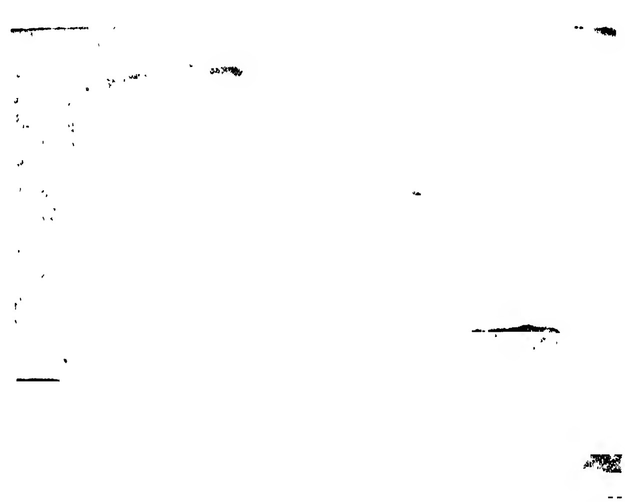
1. THE USE OF TIMBER IN BUILDING CONSTRUCTION: A HAPPY EXAMPLE.

The New Conditions of Craftsmanship. It is not to be expected that, under such conditions, he can possess a complete knowledge of the various details of all the styles in which he may be called upon to work. He depends, therefore, in these days, on full and accurate details being supplied of all work he is called upon to execute; there is, as a rule, but little scope left for the workman's individuality to display itself.

At the present day, too, to a large extent, the custom, especially in London and other large towns, is for a group of workmen to be collected together for the execution of any building, for them to be dismissed as required, and for them to be dispersed on completion of the work. The contractor, or his foreman, may keep in touch with a few of the men who have shown themselves the most capable and trustworthy workmen, and in the builders' own shops good workmen are often retained for many years; but there is nothing resembling the old guilds of craftsmen. The best workmen may still take a pride in a good bit of individual workmanship; but there is rarely room for the corporate pride in a splendid building, resulting from combined effort on the part of a great body of workmen, which must have been a notable element in building under the old conditions which have now passed. The architect, as its designer, however, and the builder who has organised and carried out the work, may take a legitimate pride in the result of their own labour, and of the work of others they have directed. The exigencies of modern conditions have concentrated in one or two individuals the functions formerly exercised by considerable bodies of workmen. Efforts have been made to some extent to revive the old conditions of craftsmanship, and under favourable circumstances they may, in a limited way, be successful; but there seems no prospect of anything like a general return to any such conditions amongst the general body of workers. The whole spirit of the times has changed; the intense desire for extreme rapidity of work, stimulated often by the enormous values attached to sites, the general introduction of machinery into all departments of work, and the facility of transit both for individuals and merchandise, seem entirely to prohibit the re-establishment of

conditions that formerly existed naturally, otherwise than as an exceptional and isolated effort. It is therefore essential, under modern conditions, that those who are to direct the efforts and work of a large or even a small body of workmen should themselves be exceptionally well equipped.

The architect, if he is to be fully worthy of the title, must be possessed of artistic powers and facility in expressing his intentions; but he must, as the basis of his work, understand thoroughly the nature of the materials he is to use, and the capacities of the workmen on whom he must eventually rely for the execution of his projects. The conditions of present-day work require that, for much of his work at least, he should keep himself in touch with all the most modern achievements in the way of construction. In most cases he must be prepared to deal with buildings of various classes, even though his work in the main should be somewhat specialised.

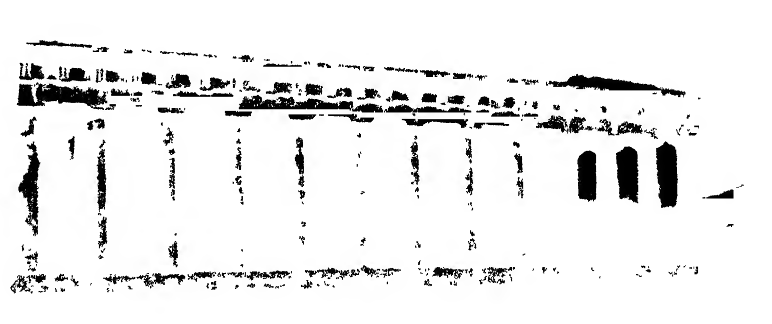


2. THE DURABILITY OF ROMAN MATERIALS: THE TORRE DEI SCHIAVI, ROME, AFTER 1600 YEARS

The Builder's General Knowledge.

The builder cannot be expected, any more than the architect, to become an expert craftsman in all trades; but he must have a general knowledge of them, and should be familiar with the capacities of workmen in various trades and the amount of work that may be properly expected of them. As in the case of the architect, he may be called upon to execute buildings, varying greatly in the purpose for which they are used, and in the system of construction; but he is furnished, as a rule, with detailed instructions in the form of drawings and specification. The builder should share with the architect the desire for the production of a sound and well-constructed building; but from a business point of view it should be his just and reasonable expectation to execute such work with a fair profit to himself. Though these interests may to some extent clash, his efforts should be directed to securing his profits by fair prices, good management and supervision rather than by the introduction of inferior material, the employment of indifferent workmanship, or any other unworthy means.

"Builder" and "Contractor." The term builder is a very wide one. It may be applied to the man who erects small suburban houses as a speculation, either a few at a time or sometimes whole streets of them, and to the man who erects work under contract, often of an extensive or valuable character. The circumstances governing the two classes of work are entirely different, and between these extremes there are many inter



3. THE IMPERISHABLE MARBLE OF THE GREEKS: THE TEMPLE OF THESEUS AT ATHENS, AFTER 2300 YEARS.

mediate grades. The suburban house must be completed to sell or let within a certain sum, if it is to have any chance of competing in the market with its competitors. For the same reason it must be finished in a style to attract those looking out for this class of house. The drains and sanitary fittings must be sound enough to pass what are usually strict and somewhat severe tests. There is often originally a fairly stiff ground rent, which the builder desires usually to "improve," and the margin left for the actual structure is often small. Under these conditions, bricks and timber of inferior qualities are often employed, and the work cut down to its lowest limits; but even in such cases a fairly sound structure may be erected by a capable man.

The builder who executes contract work, often styled also a contractor, works under different conditions. Unless his price is very closely cut, it should allow of a sound structure being erected with a fair margin of profit. Such a building is also usually carried out under the direct supervision of an architect. Usually there is also a clerk of works, whose special duty it is to keep a watchful eye on the materials and workmanship employed. Buildings erected under such conditions should be thoroughly sound and well constructed.

Cost of Structures. The cost of structures for which the best materials and workmanship are provided will necessarily be high, but such a building may be expected to prove economical. Even with the lapse of a considerable number of years little repair should be necessary, if careful attention is given to the construction, whereas in cheaply constructed buildings defects very quickly show themselves. But the best materials, almost without exception, are subject, when exposed to the various conditions of the weather, to gradual decay, especially in certain circumstances; and almost every building requires more or less watchful care to preserve it in its original perfect state. Some few buildings, it is true, have been constructed so as to defy the tooth of time, and but for accident or vandalism would have been handed down to our day almost perfect. Such are some of the best buildings of the Egyptians, the Greeks, and the Romans. In all such cases this exceptional result is due to the use of materials which in the climates in which they were employed prove to be almost indestructible. For example, the granite of the Egyptians, the marble of the Greeks [3], and the wonderful concrete formed with Pozzuolana of the Romans [2], have under favourable conditions remained to the present day in such perfect preservation that the very tool marks are still visible. In our northern climate, with its humidity and great variations in temperature, including at times prolonged frosts, even the same materials, subjected to a different set of conditions, would not have had the same permanent character.

Influence of Climate on Materials. In other countries, where the conditions of building were different, and where materials of a less permanent nature were employed, examples are afforded of the utter destruction that may follow neglect. The splendid palaces of the Assyrians and Chaldeans, which in their day were perhaps hardly less magnificent in their effect than some of the great structures of the Romans, were in the main built of sun-dried bricks, arranged in immensely thick walls and faced, both internally and externally, with materials better able to withstand the effects of the weather. Such a compound structure, with an extremely destructible core, and a comparatively thin skin of a more permanent character, may be maintained in good repair by unremitting attention; but when once this is withdrawn, the destruction is rapid, and these great palaces are marked in these days by shapeless mounds of earth, from which, however, the care of the explorer has extracted many of the secrets of the original structure.

These historical examples are recalled because they emphasise the great influence climate has upon materials, and the necessity for a thorough knowledge of this subject to the practical constructor of buildings. Even in our climate it might not be impossible to erect a building that would defy the attacks of weather; but it would be costly and could not be carried out on a large scale. Anyone who has charge of a considerable building, even though thoroughly well constructed of good but customary materials, soon becomes aware of the many quarters from which the permanence of the structure is liable to attack. Many, if not all, of our great cathedrals, for example, employ a small permanent staff of workmen, who are constantly engaged in the examination of the structure, under skilled supervision, and in the repair of the minor defects and decay that are constantly showing themselves.

Situation and Soil. No ordinary building, therefore, however well selected are the materials originally employed, can be trusted to stand for any lengthy period without attention. But the better they are and the sounder the construction, the less costly will be the inevitable work of maintenance and repair.

It may be pointed out incidentally that the very usual system of leasehold tenure has a considerable influence on the class of work commonly executed. The fact that a building, after a certain lapse of years, reverts to the ground landlord tends to prevent the erection of structures calculated to last for all time. It is held sufficient in many cases to put up such a structure as will, with ordinary attention, last out the term of the lease.

The situation of a building and the nature of the soil upon which it is erected, are further important elements in determining its durability and stability, and have often an important influence on its cost. The considerations affecting the locality of a building are various, and differ with different classes of buildings. For some few buildings a site is selected with great care, attention being paid to the aspect, the elevation above the sea, facility of access,

and similar matters, of the utmost importance in securing the health of those who are to make use of it. Such buildings usually belong to the class of hospitals, or asylums for the young or the aged, in which, within certain limits, the necessity of obtaining the most healthy situation possible, is paramount. The same is true also of private residences of a very high class

Considerations which Affect Locality. But other considerations regulate the locality of most buildings. As a rule, in the case of buildings erected for business purposes, facility of access by road, or rail, or river is a paramount consideration; in other cases the fact that a particular trade is limited to a certain district narrows the choice

In the case of public buildings, they must generally be so situated as to be in the neighbourhood of important business centres already created; in the case of dwellings for the working and middle classes they must, as a rule, be within a certain distance of their daily work.

In recent years, modern facilities of transit have had, and will have to an increasing extent as these facilities develop, a remarkable influence on this question; even for workmen of the poorest class it is becoming increasingly possible to convey them between the site of their daily labours and their homes, which may be a dozen or a score of miles distant, rapidly and cheaply. For the upper middle class, rapid railway travelling and motors are rendering districts available for residential purposes, which a few years ago would have been held to be much too far afield for those whose business or profession required daily attendance at a city office

The locality may have an important effect on the durability of a building; a low lying district, especially if marshy or adjoining a large body of water, is particularly liable to mists and damp fogs. Such a site may necessitate preliminary drainage operations, and special precautions in providing against damage from the effects of moisture, which tends to promote decay. On the other hand, a site exposed to continuous high winds in any sandy district is liable to have any stone-work attacked and slowly eaten away by the fine particles of sand carried against it. This has occurred on parts of our Eastern coasts. Generally speaking, sites somewhat open to the access of sunshine and drying winds are favourable to the preservation of materials, as they are to the health of the inhabitants.

Factors which Affect the Cost. The locality and the actual site may, as we have seen, very materially affect the cost of any structure to be erected upon it. Apart from the actual cost of dealing with difficult foundations, the facilities for access of materials, or the reverse, make a very serious difference in the cost of executing work. In almost all cases materials have to be brought for a longer or shorter distance to the site, and it is not merely the actual distance, but the amount of handling goods require, that determines the cost.

The loadingin to railway trucks or barges is a somewhat costly process for goods of large bulk and small value—*e.g.* sand, ballast, bricks; and if goods have to be subsequently transferred before finally unloading the cost is very rapidly increased. The existence of a hill necessitating the employment of a chain horse, or in cities the necessity for carrying out all soil from excavations in baskets, and often its conveyance to a distant spot before it can be deposited, are other examples of the manner in which difficulties, and consequently the cost of work, may be enhanced. Any attempt to arrive at the actual weight of materials employed, in a building of even moderate size, will make it easy to realise how such questions materially affect the cost

The nature of the actual soil upon which a building is to be erected is a matter of the greatest importance. The method of dealing with difficult sites will be dealt with in due course, but it is desirable to realise, in this preliminary stage, that, while it is possible to deal satisfactorily with the most difficult conditions, it is in many cases a matter of very great trouble, and, as a consequence, of increased cost. Much will depend on the character of the building to be erected. If, for example, it is in itself lofty, and consequently places a great load on the foundations or, even if of moderate height, if it is intended for warehousing very heavy goods, or for the reception of heavy machinery, special precautions must be taken to meet these conditions

Foundations. The best foundations are provided by materials that are practically incompressible, or which, if liable to compression, will yield uniformly. The principal foundations of this class are rock, hard gravel, and hard clay, certain others, such as loose gravel and sand, are in themselves practically incompressible, but require to be so confined as to prevent the possibility of lateral movement

Many other soils, such as ordinary clay, alluvial deposit, and all kinds of made ground, are liable to compression. Some of them are also liable to alteration in bulk, involving sometimes expansion as well as contraction, under varying atmospheric influences. Clay is particularly liable to such changes, and will be affected to an appreciable extent by either a prolonged drought or continuous heavy rainfall, this effect extending to a considerable depth below the surface of the ground.

A difficult class of site to deal with is one in which part consists of compressible and part of incompressible materials. This not infrequently occurs in the neighbourhood of London, where gravel and clay are met with

Another danger to be apprehended, in the case of natural foundations which contain much moisture, is the possibility that they may at some future time be drained by operations carried on at a different level. This brings about the withdrawal of water from the soil, with the result that the bulk of the soil will be contracted and will be followed inevitably by the subsidence of the superstructure.

The Selection of a Site. The methods of dealing with these difficulties will be described in the proper place, but we may point out here the importance that is often attached to the character of a building site, and the desirability of carefully selecting it when opportunity for doing so arises; and, in cases where the site is fixed by other considerations, the necessity of a very careful examination of it with a view to dealing with any difficulties it may present. It is well, from the first, to emphasise the fact that in dealing with the site and the means required to safely carry a building to be erected upon it, nothing that can be done to counteract all chances of future failure should be omitted.

It may well be that where the money that can be spent on a building is limited, the provision of an adequate foundation on a difficult site may involve a somewhat painful economy in dealing with the superstructure; but that is on all grounds to be preferred, to erecting a striking superstructure on an ill provided foundation, with the possibility of future disaster involving serious loss to the owner and damage to the reputation of the constructor.

One thing is quite certain—that whatever may be the cost of properly preparing a site in the first instance, it will prove immensely more costly, should a partial failure subsequently occur, to deal with the site then so as to adequately maintain the building.

Aspect. A matter that should not be lost sight of in selecting a site and arranging for covering it with buildings is that of aspect, which in some cases is of great importance.

For all purposes for which it is of importance to secure as uniform a quality of light as possible throughout the working day, an aspect north, or, better still, some few points east of north, is desirable. Windows having such an aspect will, at no time during an ordinary working day, receive any sunshine, and if somewhat east of north will not do so, even if work is carried on late in the long summer evenings.

In cases where the healthiness of a building is an important factor—and this includes all domestic buildings—it is desirable to secure sunshine at some part of the day to all windows, except those lighting rooms which it is essential to keep cool, such as larders, dairies, and similar rooms, for all of which a northern aspect is preferable. Where a site is considerably larger in area than the building that is to occupy it, there should, as a rule, be no great difficulty in securing a suitable aspect for most of the rooms, unless some natural features, or the fall of the ground, should create one. But in confined sites, such as are usually found in towns, especially in the case of terrace houses, where the front rooms are lighted from the street, and the back rooms from the back portion of the site itself, the comfort of the house will depend to a great extent on the relation of the site to the adjoining street.

The Best Streets to Live in. Streets running north and south are better for living in than those running east and west. The former secure sunshine to both the front and back windows during some portion of each day, while in the latter the windows facing south, whether at the back or front of the house, will receive a large amount of sunshine, while the northerly windows will receive none.

Some of the considerations that are likely to materially affect the operations of the builder have been touched upon, but the subject is one that can hardly be exhaustively dealt with, the circumstances varying so greatly with individual cases. But enough has been said to emphasise the importance of taking into consideration the effect that the site and its situation may have on the builder's operations. Where an architect is employed, such matters come first under his consideration, and are provided for by his disposition of the building, and by its structural arrangement. But they are matters that will require the careful attention and consideration of the builder in many circumstances.

The Building Trades. Future articles will deal with the various trades by which the work of the builder is carried out. These are divided into two principal divisions—those relating to the carcase of the building, and those dealing with the finishing of the building.

The first division begins with the work of the excavator who prepares the site and the foundations and deals with the drainage. He is followed by the bricklayer and mason, and at an early stage of the building the carpenter appears upon the scene, and the tiler or slater, with the help of the external plumber, covers in the building after the carpenter has completed the framing of the roofs.

When the building is covered in, the finishing work begins. The trades which work on the finishings are those of the joiner—who, as a rule, provides doors and windows to close the various openings before proceeding to other internal work—the plasterer, the smith and ironmonger, the internal plumber, the painter, and the paperhanger and glazier.

This order represents the general sequence of a specification and roughly the order in which the trades are employed in most buildings, but to a great extent the work of the different trades is intermixed, and the builder has to arrange for the work of one trade following on another in different parts of the same building without delay or intermission.

In these days a great many specially-manufactured articles are employed in a building, many of them patented, and as far as possible they will be dealt with in considering the trades within whose province it falls to supply and fix them.

To be continued

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BY

A. J. WINDUS, Associate in Practice of the Institute of Chartered Accountants, and County Council Lecturer on Business Methods and Machinery

W. A. BOWIE, London Manager of Scottish Temperance Assurance Company, and others

THE MASTER-BUILDERS OF OUR COMMERCE

By A. J. Windus

IN olden times men who had amassed great wealth as the result of their trading ventures were called merchant princes. Their modern successors are commonly styled captains of industry.

The distinction is not without significance. In it there lurks a subtle indication of great changes which have taken place in the domain of commerce—changes which have had far-reaching consequences. But we cannot understand these changes, nor can we apprehend the part we are to play in the business life of to-day, unless we revert to the springs of commercial intercourse at the dawn of civilisation.

The Beginnings of Commerce. Our remote ancestors were savages who roamed the forests in search of prey, or waged fierce warfare among themselves to settle the claims of rival chieftains. It is difficult, perhaps impossible, to fix the exact period when they emerged from barbarism. Long before the Christian era, however, the Phœnicians made voyages to Britain to dispose of their products, taking in exchange tin, lead, and skins. Their transactions were effected without the aid of money; there was a direct exchange, that is to say, of certain products for others. This system of trading is termed *barter*, and it marks the first stage of civilisation in a community.

The frontispiece of the SELF-EDUCATOR, Lord Leighton's picture, "Phœnicians Trading with the Early Britons on the Coast of Cornwall," conveys a very clear idea of the way in which business between our forefathers and the Phœnicians was probably conducted. Facing the picture we notice on the left hand side a group of fair haired Britons. One of them bears on his shoulder a sheepskin, which he evidently wishes to barter for the splendid piece of cloth, dyed the true shade of royal Tyrian purple, in which the ladies of the group appear so deeply interested. Now observe the group of Phœnicians on the right, especially the shrewd expression on the face of the merchant who, with hands uplifted, seems to deprecate with a sort of good natured astonishment the notion that such cloth could be had in exchange for a beggarly sheepskin. Notice, too, the vases of metal cunningly displayed in the foreground. We have a perfect conception, on coming away from this picture, of what constitutes barter in commerce.

Civilisation and Commerce. Civilisation and commerce are inseparably linked together, and the one cannot long exist without the other. This law holds good in all countries, and in all ages. It was true of the Babylonian Empire; it is no less true of the British Empire to-day.

We may define civilisation as a state of human society in which intellect supersedes brute force. From this source flows the triumph of peace over war, and directly men have learned in some measure to live peaceably with their fellows, civilisation has begun. In its infancy, it will progress but feebly. As it reaches maturity, and aided by commerce, one of its most powerful auxiliaries, we may expect it to advance with giant strides.

All this applies with undiminished force to the history of our own country. We have seen that even prior to the landing of Julius Cæsar on our shores in 55 B.C., the inhabitants possessed a rude form of civilisation. Its progress was doubtless retarded by the frequent invasions and tribal wars to which the country was subject, perhaps also by the despotic rule of the Druids. When the Romans came, they overthrew this old civilisation, and imposed their own in its stead, and Britain became a Roman colony.

How strange it seems that this happened almost by accident! Rome's foreign policy of that day was conservative rather than aggressive, and what first attracted the Romans to Britain was the desire for pearls rather than conquest. The pearls, though abundant, were inferior and of little worth, but the Roman legions acquired for their master one fair jewel, and that was this land of ours, "the precious stone set in the silver sea."

Basis of Our Merchant Law. The influence of the Roman occupation upon our national life has proved ineffaceable. Its stateliest monuments do not consist in the famous military roads which the Romans constructed, nor in the remains of city walls like those of London and St. Albans, nor in any of these things. They consist in the large number of words of Latin origin which the Romans added to our language, and in the imposing fabric of Roman Law which they built up. Although this did not remain intact, its substance entered largely into all our future codes. Thus the section relating to trade customs and requirements became the nucleus of the Law Merchant, or *Mercantile Law*, whose provisions govern the transactions of all classes of business men to-day.

The Roman legions retired finally from Britain in A.D. 420. In a few years the Saxons came, and were joined about a century later by the Angles. Gradually these two nations became one, the people were called Anglo-Saxons, and their country England. In the early part of the ninth century the Danes began to raid the English coast. Like the Anglo-Saxons, they ultimately obtained a settlement in Britain. To cope with these freebooters, King Alfred built and equipped a number of war vessels, and thus originated the British Navy, the visible protector of our oversea commerce. Alfred died in the year 901. Because of his immense contribution to the welfare of his country, history has conferred upon him the surname of "the Great," and never was a title better bestowed. The incursions of the Danes continued long after Alfred's death, but some time previous to the Norman Conquest the fusion between the Anglo-Saxons and the Danes had become so complete that they were all regarded as one united Anglo-Saxon people.

Trade in Saxon England. The records of Saxon commerce are few and meagre, but one of the statutes of King Athelstan, wherein it was decreed that the merchant who had made three long sea voyages should be ennobled, shows the esteem in which persons engaging in foreign trade were held. The Norman Conquest of 1066 deserves more than the fleeting notice we can give it. Its first fruits were evil. Untold misery became the lot of already unhappy people, who found the harsh yoke of the existing Feudal System riveted more firmly than ever upon their necks. The development of commerce was arrested. But there is another side to the picture. The superior civilisation of the Normans was grafted on to the English stock. Saxons and Normans coalesced, and finally there was produced that "happy breed of men" of which Shakespeare was to write.

The national character was a harmonious blending of the qualities peculiar to the several races who had formerly overrun the land. The Romans, for example, had inculcated respect for law and order. Among the Saxons, Christianity had asserted its benign influence, and fostered the love of justice and fair play. The thirst for maritime adventure sprang from the Danes, while the Normans had transmitted a desire for the arts and refinements of civilisation. These types were reproduced in the nation at large.

Royal Enemies of Commerce. We have now traced the principal elements of which the English nation is compounded. Before passing from the twilight of the Middle Ages into the broad daylight of our modern times, let us gaze for a moment on the state of commerce in the former period. For some time, the Jews were the chief, though not the sole traders. They also engaged largely in the business of money-lending, at high rates of interest. Their wealth and extortionate practices made them objects of envy and hatred, and in the reign of Richard I. many of them were massacred and their [illegible] plundered. The Jews suffered further persecutions in succeeding reigns, and Edward I., in 1290, banished them from England. Any benefit which might have accrued to the non-Jewish trader from this policy of exclusion was, however, more than counterbalanced by the arbitrary interference of monarchs with the natural course of trade. Grievous burdens and restrictions were laid on importers and exporters alike. Three instances will suffice:

1. All through the reigns of Edward I., Edward II., and Edward III., goods for export could be sold in certain places only, sometimes here, sometimes on the Continent, and these places were constantly changed at the caprice of the king.

2. During the reign of the first Edward a decree was made, and remained in force for twenty-eight years, that foreign merchants entering the country were to sell their goods within forty days of arrival, and were not to stay longer except by special licence.

3. When Edward III. engaged in naval warfare he issued press-warrants, under which merchant-vessels were forcibly seized wherever they were found, and added to the king's navy.

Growing Freedom for the Merchant. Internal trade was chiefly carried on by means of fairs. When the king wanted money, special fairs were proclaimed. One would be set up in

a certain district, and all the shops and markets within a greater or lesser radius would be deserted for the time being, while the traders would take their wares to this fair, where they were obliged to pay all sorts of taxes and impositions, for the benefit of king and nobles. Under the guise of tolls, they were also robbed on the way thither by the barons through whose lands they had to pass. Sometimes a national fair was proclaimed, at which these exactions were repeated on a larger scale. During its continuance, not only shops were closed, but all the local fairs throughout the kingdom.

In spite of all obstacles, however, the genius of the people for commercial enterprise began to assert itself, and would not be denied. The growing power of the famous Hanseatic League, of which we shall learn more hereafter; the discovery of coal; the invention of the mariner's compass at the beginning of the fourteenth century; the creation of a native gold coinage, the use of *Bills of Exchange* to which traders had become accustomed under the tuition of Jewish and Lombard merchants; the encouragement given to Flemish weavers to settle in the kingdom; the abolition in the law courts of pleadings in a foreign tongue—these, together with many other causes, combined to check the forces of tyranny and restraint, and gave a powerful stimulus to the spirit of commerce.

A Mighty Edifice. It is not within our scope to continue our study of commercial history beyond this point. We have been present in thought when the foundations of our commercial prosperity were being laid, and we can form some notion of the superb edifice which has been raised upon it. Although we cannot ignore entirely the work of master-builders of past generations, our examination of the mighty superstructure which has risen upon their foundations will be confined chiefly to its aspect in the present day, and to the latest methods and machinery employed in its enlargement and improvement.

One last remark on the older portions of the structure is necessary, however. The English were engaged alone upon it for a long time—until the death of Queen Elizabeth in 1603. In that year, James VI. of Scotland became James I. of England. The crowns and peoples of the two countries were united, and thenceforth English and Scottish merchants laboured side by side upon the stately fabric of British commerce.

If merchants are the master-builders of commerce, we may affirm that clerks are their apprentices and journeymen. Formerly, when an apprentice had served his time and mastered his craft, he was styled a journeyman. To fit the apprentices of commerce for journeyman's work—to teach the junior clerk, in other words, the duties of his own grade and of all superior grades of clerkship, and to instruct clerks generally—is the task which lies before us. It is our business to bring before our readers the clerk's great opportunities, and to help him, as best we may, to realise them.

Synopsis of the Course. It is intended that this course of study shall be of real value in the first place, to one who is at the outset of his career, giving him a clear idea of the openings to commercial life and helping him to qualify for steady advancement from the ranks. But the course will appeal to many who have already acquired a good knowledge of the rudiments of office-work, and who need instruction of a more advanced kind, or who wish to specialise in some department to which their tastes or talents incline them. Of such a little patience is demanded when they find that early chapters treat of the duties of the office boy and junior clerk, or explain the elements of bookkeeping, and all students are advised to become familiar, without loss of time, with the vocabulary of commercial terms and phrases which precedes this introductory chapter. There will be articles, as the course develops, dealing with more complex accounts and with the various instruments of commerce.

Consideration of the theory and practice of double-entry, of self-balancing ledgers and adjustment accounts, of balance sheets and profit and loss accounts will provide material for study on the part of those who wish to master modern bookkeeping. The application of this knowledge by clerks in representative business concerns will naturally be dealt with, and there will be full chapters on import and export trade and foreign exchange. Another article on the importance of specialisation gives valuable suggestions as to lines of study to that end, and factory accounts and Prime Cost Systems, will find their due place. Large numbers of young men are engaged as ledger clerks, cashiers, and secretaries to limited liability companies, and for these company accounts will be carefully treated, the relation of statutory to financial books explained, and the duties of company secretaries set forth. Those seeking guidance in accounts which must be prepared in a form prescribed by law have not been neglected, and there will be also a chapter for audit clerks, articles on the Stock Exchange, and a chapter dealing with confidential clerks.

The Clerk's Prospect. But the subjects do not exhaust the interest of this course, for not only will the student be informed of standard text books, by means of which he may deepen his knowledge, but the SELF EDUCATOR contains sections having an important bearing on his professional education, which he should carefully follow.

The clerk who has had a fair education, and will take pains to improve it, whose integrity and perseverance are undoubted, need place no limit to his career in commerce. His ambition may carry him higher than clerkship. But the importance of steady application must be insisted on. The manager, or principal, who is looking for a man to promote, will more readily recognise the claims of one who devotes some of his spare time to study, and whose progress is punctuated by success in such examinations as are open to him.

To be continued

EXAMINATIONS FOR THE COMMERCIAL PROFESSIONS.

Examining Body and Grades	Age Limits	Time and Place of Examinations	Subjects of Examinations. Obligatory	Subjects of Examinations. Alternative or Optional.	Fees.
CHARTERED INSTITUTE OF SECRETARIES. Preliminary	Not under 16	London. June and December	Dictation, English Grammar and Composition, English History, Geography (mainly British), Arithmetic, Algebra (including Quadratics), Euclid, Books I and II.	Two of these (one a language): Latin, Greek, French, German, Italian, Spanish, with easy translations, Questions in Grammar, Higher Mathematics (Algebra, Trigonometry, Euclid), Physics (Mechanics, Hydrostatics, Pneumatics), Chemistry, Animal Physiology, Electricity and Magnetism, Light and Heat, Geology, Shorthand (70 words a minute).	£1 1 0
Intermediate	Not under 19	London June and December	Correspondence, Filing and Indexing Documents, Precis Writing, Drawing up Reports, Preparing Minutes, Commercial Arithmetic, Bookkeeping and Accounts, Mercantile Law	One of these: Political Economy, Company Law, French, German, Italian, Spanish, or other language approved by the Council	£1 11 6
Final	Not under 21	London June and December	Correspondence, Procedure at Meetings, Preparing Minutes, Reports, etc., Precis Writing, Commercial Arithmetic, Bookkeeping and Accounts, Mercantile Law	One of these: (1) Company Law and Accounts; (2) Law and Accounts relating to one of these: Municipalities, Railways, Canals and Docks, Gas and Lighting, Waterworks, Banks, Insurance, Mining, Hospitals; (3) French, German, Italian, Spanish or other language approved by the Council.	£2 2 0
INSTITUTE OF ACTUARIES			See Insurance Section		
INSTITUTE OF CHARTERED ACCOUNTANTS IN ENGLAND AND WALES. Preliminary	None	London, Birmingham, Manchester, Newcastle-upon-Tyne. June and December	Generally the same as in No. 1 Preliminary, but Elementary Latin required, and Euclid Books I to IV	Generally the same as in No. 1 Preliminary	£2 2 0
Intermediate	Dependent upon age when articled	London. May and November	Bookkeeping and Accounts (including Partnership and Executorship Accounts), Auditing, Rights and Duties of Liquidators, Trustees, and Receivers.	None	£2 2 0
Final	Dependent upon age when articled	London. May and November	Same as Intermediate and in addition Principles of Bankruptcy and Company Law and Law. Principles of Mercantile Law and Law of Arbitrations and Awards.	None	£2 2 0
INSTITUTE OF BANKERS			See Banking Section		
LONDON CHAMBER OF COMMERCE.† Junior.	None	London and Provincial Centres. Evenings in May and June.	English Grammar and Composition (including Handwriting, Dictation, Spelling, Essay and Analysis, Arithmetic (including Mental Arithmetic), Tots, (Metric System), a Modern Foreign Language, comprising Translation, Dictation, Composition and Conversation. Commercial Geography and History, Elements of Political Economy.	Generally as in No. 1 Preliminary; from two to four subjects may be taken. Bookkeeping in addition.	2s 6d per subject.

Examining Body and Grades	Age Limits	Time and Place of Examinations	Subjects of Examinations: Obligatory	Subjects of Examinations: Alternative or Optional	Fees
LONDON CHAMBER OF COMMERCE † Senior	None.	London and Provincial Centres Evenings in May and June	English Literature, History and Geography, Foreign (including Oriental) Languages, Mathematics, Commercial History and Geography, Elements of Political Economy	Two of these: Mathematics (including Trigonometry), Methods and Machinery of Business, Banking and Currency, Commercial and Industrial Law, Bookkeeping and Accountancy, Chemistry, Drawing, Shorthand, Typewriting	[illegible]
SCOTTISH CHARTERED ACCOUNTANTS GENERAL EXAMINING BOARD. Preliminary	None	Edinburgh, Glasgow and Aberdeen June and December	Dictation, English Grammar and Composition, Arithmetic, Elementary Algebra, Simple Equations	Three of the following: British History, Geography, Euclid Book I, Shorthand, Latin, French, German	[illegible]
Intermediate	Dependent upon age when apprenticed	Edinburgh, Glasgow and Aberdeen June and December	Mathematics: Arithmetic, Algebra (including Quadratics and Logarithms), Bookkeeping, Framing Accounts and Trust States [illegible]	None	[illegible]
Final	Dependent upon age when apprenticed	Edinburgh, Glasgow and Aberdeen June and December	Law of Scotland, Actuarial Science, Political Economy, Accountancy	None	[illegible]
SOCIETY OF ACCOUNTANTS AND AUDITORS Preliminary	None	London, Manchester, Edinburgh, Dublin June and December	Arithmetic, Dictation, English Grammar and Composition, English History, Geography, Algebra (including Equations and Fractions), Euclid Book I, Two of these languages: French, German, Latin, Elementary Easy Translation and Questions in Grammar	None	[illegible]
Intermediate	None	London, Manchester, Edinburgh, Dublin June and December	Bookkeeping and Accounts, General Commercial Knowledge, Adjustment of Partnership and Executorship Accounts, Law relating to Partners and Executors, Rights and Duties of Liquidators, Trustees and Receivers	None	[illegible]
Final	None	London, Manchester, Edinburgh, Dublin June and December	As in Intermediate with Auditing, Mercantile Law, Law of Arbitrations and Awards, Company and Bankruptcy Law.	None	[illegible]
SOCIETY OF ARTS Elementary	None	London and Provincial Centres Evenings in April	Handwriting, Shorthand, Elementary Bookkeeping, Commercial Arithmetic	Commercial Geography, French, German, Spanish, Italian, Typewriting	[illegible] for first and 1s. for each additional subject
Intermediate	None	London and Provincial Centres Evenings in April	Arithmetic, Bookkeeping, Précis Writing, Shorthand, A Modern Language	English, Commercial History and Geography, Typewriting, Economics, Modern Languages including Oriental	2s. 3d. per subject
Advanced	None	London and Provincial Centres Evenings in April	As in Intermediate	As in Intermediate with Commercial Law and Accountancy, and Banking	2s. 6d. per subject

* To have passed the Matriculation Examination of London University is accepted as a proof of ability and exempts a student from the Preliminary Examinations of most professional bodies. In a modified sense the same is true of the Local Examinations conducted by any of the Universities. The newer Universities attach increasing importance to the business side of education, and, in particular, the University of Birmingham confers Degrees in Commerce.

† Students residing out of London should ascertain if Examinations are conducted by the Chamber of Commerce nearest to them.

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STITCHING AND ALL ITS VARIETIES ILLUSTRATED

By Azeline Lewis

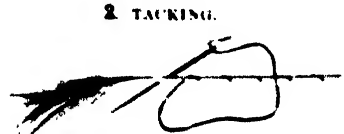
BEFORE we can reach the ornamental stages of dressmaking it may be as well to run over the different stitches which go to build up that rare commodity so dear to a woman's heart a perfectly fitting gown.

Basting or Tacking-out Stitch. This stitch is used for fixing the pieces of lining and material together. It is worked upwards, with the needle placed horizontally and pointing to the left [1].

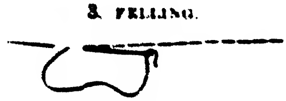
Tacking. This is used to fasten the bodice seams together, and to mark straight lines, centre of bodices, darts, and for portions of skirts, securing down a hem before stitching, and, wherever necessary, to unite two portions to keep them from slipping before finishing off. It is made by passing the needle and cotton in and out of the material in a horizontal direction, taking up a small piece of material and passing over a larger piece. Sometimes the stitches may be fairly long, but the size of these depends on the portion tacked. If there is any strain, as in bodice seams, the stitches should be fairly close, like coarse running, and an occasional back stitch will prevent any slipping apart [2].

1. BASTING

2. TACKING.



3. FELLING.



4. STITCHING.

Felling. Felling is the same as hemming, except that the needle is inserted at the top of the fold instead of at the bottom. It is used for neatening seams, facings, etc. [3].

Running. In this stitch the needle is passed horizontally in and out of the material, in the same way as tacking, only much closer together and at equal distances. Several stitches are done at once.

Stitching. In stitching the needle is also used horizontally to take up a small piece of the material. The next stitch is of equal length, and must be taken right back to meet the stitch last made. Each stitch should be taken over the same number of strands of the material, so that the stitches are perfectly regular [4].

Back-stitching. This is similar to stitching, only the needle is put half-way back to meet the last stitch, instead of right back to where the needle was taken out. It is, however, generally used to mean running with an occasional stitch half way back. It keeps the running or tacking firmer.

Overcasting. This stitch is used not only to neaten the raw edges of seams, but also to prevent them from fraying after they have been cut away and notched as in a bodice. In the former, the stitches are taken over the edge in a slanting direction, a little distance apart, the needle being used from left to right. All the stitches must be of equal size; but as some materials are much worse than others with respect to their fraying capacities, judgment must be exercised as to the depth the needle is inserted in the material. The thread should not be pulled too tightly, or it will cause the seam to drag and prevent it setting well [5].

Loop-stitch. Loop stitch is also used for neatening the seams; but it is not quite so good as overcasting, and must be done fairly loosely, so as not to drag at the edges. The same stitch is used in working silk loops for fastenings over the bars of silk [6].

Slip-stitching. This is a stitch used in dressmaking to fasten down, invisibly, folds, collar and cuff-facings, etc. It requires care in working, and the material should be held lightly but firmly, particularly in the case of velvet, as the pile would be much injured if held tightly. Turn down the fold—if a hem, and not already done—thread a fine needle with fine silk to match the material, slip it in so as to take up only a thread or so of the material under the fold,

draw out carefully, and insert the needle along the turned-up part, and just inside the edge of the fold, so that the stitch will not be seen; draw out and again take up a thread of the material, and so on till the hem or facing is done. If worked carefully, no sign of stitching will be visible. The needle is passed from right to left [7].

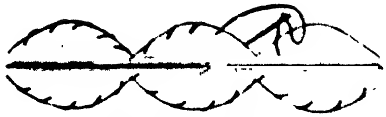
Herring-boning. This is used to fasten down raw edges to make them set flat before putting on facings, etc., and also in some thick materials to take the place of hemming.

If used to fasten down two pieces of material, it is not necessary that the stitches which come on the fold should be carried through both thicknesses of material. It is worked from left to right, the raw edges towards the worker, each stitch being a little distance from the other so that they cross each other, as in the diagram. As this is only used for keeping down edges it need not be as closely done as in plain needlework, and the thread should not be pulled too tightly [8].

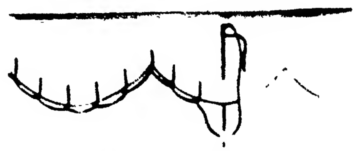
Faggoting. This stitch is now so much used for uniting strips of lace, ribbon, etc., and in many and various ways in the making of fancy yokes and cuffs for transparent blouses, that it must now be included in dressmaking stitches.

In diagram No. 1 we see that in working the stitch the needle always points downwards, also that at the top of the opening the thread lies to the *right* of the needle, at the bottom—illustrated by a broken line—it is to the *left*.

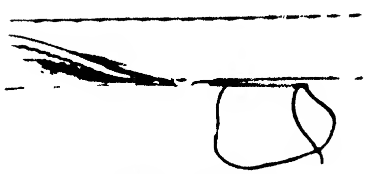
This sketch gives cross-cut bands as the medium, which must be turned in evenly to face and well pressed, and in the case of stiff material they must be tacked at the edges. The tacking should be closely done, or the bands will get dragged out of shape [9].



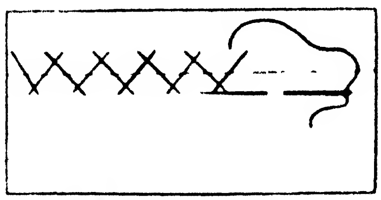
5. OVERCASTING.



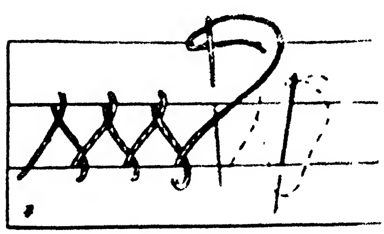
6. LOOP STITCH.



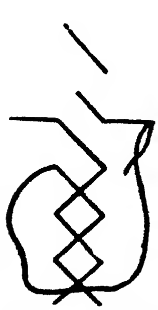
7. SLIP STITCHING.



8. HERRING BONING.



9. FAGGOTING.



10. CROSS-STITCH.

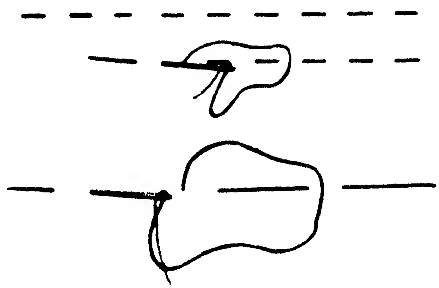
11. FAN-STITCH.

Cross-stitch. This is much the same as that used in embroidery, except that it is larger, and is worked with twist. It is used to fasten the tight band to the bodice, also to mark centre band of skirt. The working can easily be seen from the diagram, and each stitch should be three sixteenths to about a quarter of an inch long. Large cross-stitch is used to fix on tight bands, the stitch, however, only forming one large cross the width of band, and the centre threads are caught together several times to keep them firm. The needle in the upper and under threads of large cross stitch must each time be passed under the bone or steel of the bodice to keep it firm [10].

Fan-stitch. This stitch is used to fix the bones, or steels, firmly to the seams of bodice. Thread the needle, which should be a strong one, with the twist, pass it under the bone to the front, and through the hole made in this, as described later on in the directions for bodice. Make a long stitch of twist in the centre, bring the needle again to the front through the same hole, then work another stitch to the right a little shorter and lower, bring the needle again back through the same hole at bottom and work another to the right of that last made, but a little lower. Make two more on the left of the same length, starting each from the same hole, then bring the needle back to the front, pass it, eye foremost, through the stitches at the stem to hold them in place, put needle through to underside, fasten off firmly, and cut off twist. In some cases it is as well to make seven instead of five stitches when fanning the bones [11].

Gathering. This may be done in two ways: either with the short running stitch, or by taking up a small piece of material, and

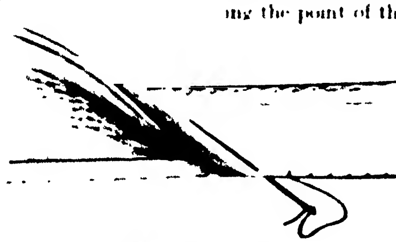
passing over a larger space. The former is used for gathering frills, and anything where the gathering must be close and even, the latter where much fulness is to be put in a small space, as in the waist part of full skirts, and particularly at the centre back, where the greater part of the fulness must be arranged. In this latter form of gathering you take up, say, one-eighth of an inch of material and pass over a quarter to half an inch according to requirements, the gathering, of course, being done on the right side of material. In ordinary gathering the needle should be held quite steady, and the material fulled on to it. For thin materials a long needle is best, so that a good many stitches may be done at a time in order to get over the ground quickly. If two or more rows of gathering be needed, each stitch must be exactly even with the one above [12]. Gauging is another term for gathering.



12. GATHERING.

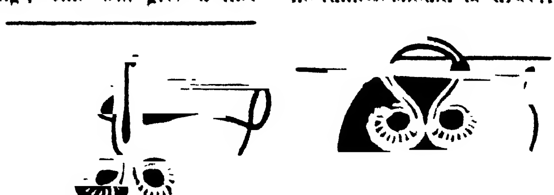
Shirring. This is the term given to several parallel rows of gathering, either plain or done over a fine piping-cord.

French Hem. This is sometimes used to finish off the edges of crossway flounces, and to make them stand out well. To do this, fold over about three quarters of an inch from the edge on the right side of the crossway strip (see that this is even and does not twist), then run along quite close to the edge of the fold just made. Now turn in the extreme edge on the wrong side about a quarter of an inch, and hem down to the ridge made by the running; this will give a nice rouleau hem on the right side, which should not be pressed. When cutting for such a frill about half an inch extra should be allowed for the turning for hem [13].



13. FRENCH HEM.

Hooks and Eyes. These are firmer if sewn on with loop stitch, the tails or bills of the hooks one-eighth of an inch inside the edge of bodice, whilst the heads of the eyes should be one-eighth of an inch beyond the edge of bodice [14].



14. SEWING ON HOOKS AND EYES.

Loops and Eyelet Holes. These are used for hook fastenings, when the material or making is not suited to eyes or bars, as in transparent or thin materials, fancy yokes and cuffs, unlined blouses, etc. For loops, first make a bar of two or three threads of twist, according to the size of the loop, and the material it is worked on, as thin or transparent goods require smaller loops than, for instance, a woollen material, and of course much depends on the purposes for which they are required. Make the bar about a quarter of an inch in length, then work the threads over with loop-stitch, working from left to right, and passing the head or eye of the needle under the bar of threads, so as not to catch in the material. The stitches must necessarily be quite closely together [15].

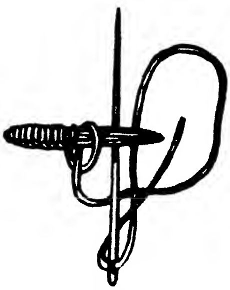
Eyelet holes are used in some cases instead of loops or eyes. In these the hole is made with a stiletto, and worked round closely in over-casting stitch, inserting the needle about one-eighth of an inch in the material when doing so. The hole should afterwards be rounded by passing the point of the stiletto through from underneath, just enough to open it, and no more. If for lacing, loop instead of over-casting stitch, closely worked, is best [16].

Easing. This is a term much used in dressmaking, and one that is more frequently misunderstood than any other. It does *not* mean puckering or gathering, but just fulling the material so that the one part shall set quite easily on the other. Either holding the part to be eased over the hand when doing it, or placing this portion uppermost, or towards the worker, will give what is known as easing, in which no fulness should be discernible.

False Hem. This is a piece of double material the same width as the hem, stitched with this on the wrong side to form a wrap for fastenings of unlined bodices, etc., or anywhere where these are better invisible.

Piping or Cording. This is now used mostly for ornamental purposes, to finish off the edges of revers, cuffs, etc., and not, as some years ago, for putting in the sleeves, or edging the basques of bodices. For single piping, cut a strip of material exactly on the cross, about one inch wide, join all the seams evenly, press open, snipping the selvedge, or cutting off the edges

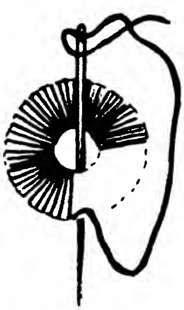
of these; place the piping cord in the centre of the crossway strip on the wrong side, fold over the other half of the bias strip, and tack or run along, quite close to the cord, pushing this up into the centre. For double piping, cut a crossway piece about two inches in width, fold over half an inch, place and run the cord in the fold, exactly as for single piping. Now fold the remainder of the width in half, place the cord in the centre of this, and with the thumb and fingers of both hands arrange it firmly in position above the first cord, being careful to keep the cord tight and not to let the crossway strip twist. Then tack closely to the cord. When sewing on piping, be careful not to stretch or pucker the edge, and when finishing off, cut the cord (not the material), so that it shall be just level with the end of whatever has been ornamented in this way [17].



15. LOOPS.

Button-holes. For some time past button and button-hole fastenings have not been so much in evidence as the other, and more invisible, fastenings now in vogue. How to work a button-hole is, however, indispensable knowledge to a dressmaker, or to anyone aspiring to sartorial attainments. For the preparation of the front for the button-holes, see Part III., where the directions are given in bodice-making.

In making button-holes, it is of great importance that they should be cut straight; a flat rule with a straight edge can be employed in making the requisite line. If there is a series, see that they are of equal distance apart, and all the same size. A tape measure can be used for this. The first button-hole should be worked on the waist line. The edge of the button-hole should be cut one-sixteenth of an inch away from the front fitting line, not from the edge of the bodice; the hole must be cut a quarter of an inch longer than the diameter of the button. The distance between the button holes is from three-quarters to one inch, according to the size of the button. Fancy buttons are placed half an inch apart. When the button-hole is marked, before cutting, stitch round the mark to prevent the material and lining slipping apart. Then cut with button-hole scissors and work one at a time. In the diagram the last stitch is separated from the others for the sake of clearness.



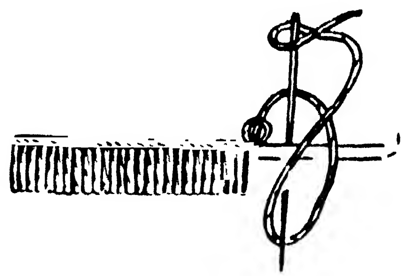
16. EYKLET HOLES.

Working the Button-hole. Take a needleful of silk twist, No. 12 for cloth, 14 for material (this is medium twist) about three-quarters to one yard long, with a No. 5-6 needle. Use the twist double to bar the edge before

17 PIPING

working to make this firm. Insert the needle between the material and facing to hide the knot, bring it up about one-eighth of an inch from the edge of the left side of the hole, carry the twist straight along, insert the needle in the material, and bring it up again at the same place, making long stitches, or a bar, round the edge, and so on, back to where you commenced, keeping the bar slightly tight, and taking care that it lies along the hole at equal distance from the edge.

The button-hole is worked with single twist. Insert the needle when working as closely as possible to the bar, but before pulling it out,



18 BUTTON-HOLING.

twist the thread over the point of the needle to the right of worker, to form the purl, or ridge at the edge of the hole. The needle should then be pulled out, the hand being drawn upward and forward, setting the loop, or purl, exactly on the edge of the hole. When the eye is reached, the stitches should be rather closer, and the purl well thrown up at that part. Repeat the process, stitch by stitch, until the hole is finished. Now bar the bottom or end of the hole by passing the needle across the end three or four times. To work the bar, the front of the bodice is held with the eye of the button-hole towards the worker. Three or four loop stitches are now put over the bar to make the ends neat and firm. Having completed the bar, the needle is passed through to the wrong side, and the thread fastened off with two or three invisible stitches. When finished, tack or sew the edges together in the middle and press on the wrong side [18].

How to Sew on Buttons without Shanks. This is a very important detail, and as the "mere man" is very fond of reproaching

woman for her ignorance of the art of sewing on buttons, it behoves her to pay attention to this paragraph. Buttons should be sewn on loosely with strong thread When doing so, place the knot of the thread outside the material, under the button, or between the outside and the facing; put the needle through the hole, and bring it down through the opposite hole, but before pulling the thread tight, place a bodkin through the loop, and continue to work two or thr e more strands over the bodkin Before removing the bodkin, bring up the needle to the sides of the button tightly, and quickly twist the thread round the button between it and the material to form a thread shank Fasten off with two or three back stitches under the button The loose sewing on and the winding round the threads really increase the durability of the work, besides allowing for the thickness of the material Buttons with shanks should also be sewn on loosely with strong cotton

Hook and Bar Fastenings. The preparation is the same as for button holes, as described fully in the making of the bodice Tack down turning of front a quarter of an inch from the fitting line, leaving three quarters of an inch for the turn-down This should be tacked and pressed. Then serge the raw edge to the lining, and tack with white cotton on the right side of the bodice This is a guide for putting on the hooks, which are sewn on with the edge of the bill just touching the white cotton on the turn-down The bars are sewn on the fitting line of the left side of bodice, the eyes of the bars being placed towards the edge of the bodice, the long edge of the bar on the fitting line The right side of the bodice is faced as for hooks, the left side the same as for buttons.

French Seam. Also called mantua-maker's seam This is much neater than over-casting for thin, unlined materials, as when these are of a very "frayey" character the latter is not enough to keep the raw edges from ravelling Place the two edges to be seamed together, and run along, on the right side, about one eighth of an inch from the edge. If the material be slightly on the cross, be careful that the thread is neither too slack nor too tight. Cut the ravelled ends of the joined portions, to prevent them sticking out when the seam is done, turn over, and crease to keep the stitching near the top, and either run or machine along quite close to the edges which have just been turned over. Be very careful to keep the stitches close up to the turned in edges, or there will be a fold on each side of this, and the seam will not be straight. Also be careful not to pucker the material in the second running, for which reason the beginner had better tack it along before doing so.

Tucking. This plays a very varied and also ornamental part in dressmaking. A tuck may be defined as a fold of material, either run or machined at certain distances from the edge. Tucks may vary from one sixteenth and one eighth of an inch (when they are generally designated pin-tucks) to one inch and more in width, and are employed in a variety of ways for ornamentation on bodice, sleeves and skirt. They are usually worked on the straight of the material. When done by hand, fold over and crease the material for the first tuck, take a strip of card, cut a notch in it the width the tuck is to be, run along, keeping the point of the needle always even with the notch. If preferred, it can be tacked before running For the next tuck, measure the space to be between the first and second, and make another notch ; this will give the place for the crease of the second tuck, which must be the same as the first The other tucks must be made in like manner. With regard to the spacing, see UNDERCLOTHING Most of the tucking is now worked, however, by machine—with or without the aid of "tuckers"—and of late is generally done by pleating the material to the depth required for the tuck and then stitching through the three thicknesses on the right side, once, twice, or even more, as desired This way keeps the tuck quite flat, and brings the stitching more in evidence, which, if a contrasting colour be employed, makes a pretty finish.

The Use of the Sewing-Machine. It will be well for the amateur to practise a little on the machine, either with hand or treadle, to see that she can work this smoothly and keep the seams even with the tack marks, as a slight deviation in a seam may make a considerable difference to the set, and, of course, will make it uneven

When about to machine-stitch the seams, thread the needle with the cotton required, which will depend on the material to be stitched. For serges, soft woollen goods, cashmere, etc., No. 40 cotton for the shuttle, and No. 50 for the needle For very thick woollen materials, No. 40 should be used for both upper and under cottons, whilst for very thick, hard materials, or cloth, No. 30 cotton should be used for both shuttle and needle.

Fine materials, as muslin, silk, etc., will require No. 50 for the shuttle and No. 60 for the needle. If coloured cotton be used for coloured goods, see that this is a shade darker than the material, as it always works in somewhat lighter.

See that the tension is right before starting ; if too tight the thread will snap

To machine-stitch the seams of the bodice, place the seam underneath the needle, let down the foot, or presser, and start the machine, guiding the work with the hand to keep it straight and steady. When the seam is done, loosen the top cotton a little to prevent it dragging, and so breaking the needle, lift up the presser, remove the work from the machine, leaving a long end of cotton on both the work and the machine ; thread a needle with the end of that remaining on the work, and finish off with a few stitches. There are many makes of machines on the market, but Singer's and Wheeler & Wilson's are too well known to need recommendation. Of the latter make, No. 9 is the best for general dressmaking purposes.

To be continued

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CIVIL ENGINEERING AS A PROFESSION

By Professor Henry Robinson

THE profession of a Civil Engineer includes all branches of engineering practice, and involves sufficient knowledge of them to enable the engineer to bring to bear on any work he has to carry out a skilful appreciation of the best known methods which may be applied. To successfully comply with these conditions requires a mind capable of acquiring and utilising a great variety of technical experience, and the preparation for such a career involves the assimilation of theoretical and practical knowledge over a wide range of subjects, and the avoidance of specialising at too early a stage.

A Civil Engineer's Training. The training of a civil engineer may be compared to that required for a medical practitioner, who obtains his qualifying degree after a definite course of study and practice in all that pertains to medicine and surgery, although in his subsequent career he may devote himself to a special subject: so civil engineers are often identified with some particular branch of the profession.

Although the great English engineers of the last century attained their eminence without such training, the conditions which engineers of the future have now to meet are widely different from theirs. In this country the training-schools have come into existence largely through private enterprise, and not through national aid. In Germany, America, Switzerland, and elsewhere the State has founded training-schools with the best equipments, and the most skilled teachers, the whole matter being dealt with as one of national importance. The result is that English experts meet in competition better-trained men from outside. This has been recognised, and is being remedied to some extent. Too much emphasis cannot be laid on the necessity for adopting a well considered system of training and enforcing it. At the present time the arrangement of the subjects that are dealt with in many of our technical schools is largely governed by the predilections of one or more of the teaching staff. If a youth has a definite career marked out for him, so that he knows that he will be associated with mechanical, electrical, mining, shipbuilding, or other branches of work, his training admits of variation and limitation to meet this, but the preparation for the profession of civil engineering requires a broader basis to admit of future developments in any required direction. Much more could be done during the school period to prepare for this. The preliminary education, which precedes what may be termed the academic, or college, training, admits of adaptation to meet the requirements of modern life, and the heads of many of our great schools are recognising this. If a youth remains at school until he is seventeen, he should have the foundations laid for some of his subsequent work. A part of his school-time could be devoted to drawing, physics, chemistry, workshop practice, mineralogy, and such subjects as would be useful in a general education even if the youth is not destined to follow engineering.

Function of the Engineer. In settling the course of training at the academic period, as distinguished from the preliminary, or school, period, the aim should be to enable the student to obtain a clear grasp of what has been arrived at theoretically and practically in the past, whilst pointing out also the direction to take for future developments. An intelligent youth is more likely to apply himself to mastering information if he recognises that the knowledge he is assimilating is capable of utilisation.

The function of the engineer has been defined as "directing the great sources of power in nature for the use and convenience of man." To embrace all this in the term Civil Engineering involves a carefully considered course of preparation both in theory and practice. How can this be best accomplished? A technical college should be arranged so as to be capable of giving the preliminary training, both theoretical and practical, and the training should be on as broad a basis as possible to enable the student to adapt himself to the varying and unknown conditions of his future career. To specialise his instruction would be likely to confine his sphere of action within such narrow limits that, unless he can find the exact opening in which that special knowledge is required, his time would have been practically wasted.

Is Workshop Practice Necessary? It is held by many that the practical information to make a civil engineer can only be obtained by passing some time in workshops either before or during the college training. This view is based on the assumption that it is essential for a civil engineer to know about workshop practice, and is the survival of old tradition applying to the time when engineering was practically limited to mechanical work. Some who advocate a year or more in workshops before the youth enters upon what is termed the academic course contend that by following this plan he can ascertain whether the engineering profession is one which he desires to follow. If the civil engineering profession could be judged by such a course, the youth would probably wonder whether his time could not be better employed than in devoting valuable time to learning in the shops where he is at work all the details of manufacture of some particular machine or apparatus that is being made there. Sir William Ramsay quite lately expressed a similar opinion. "In my opinion," said he, "far too much stress is laid nowadays on what is called practical work. To take my own subject, it is possible to have quite an intelligent idea of chemistry without ever having handled a test tube or touched a balance. Lectures on chemistry may be well illustrated experimentally, and the necessary theories demonstrated by the lecturer. Of course, that will never make a chemist, but we are not talking of making chemists, we are discussing the best way of giving education, and I maintain that to spend several hours a day in practical work is, if not waste of time, at least a work of supererogation."

An illustration of this may be given in the case of a civil engineer, now at the head of the profession, who started life under the conditions laid down—namely, of a year or more in workshops before entering upon the academic period. After passing a few months in one workshop, doing the same work day after day, he succeeded by strong influence in getting a change to another shop, where he had a similar experience. He endeavoured to arrive at an understanding of some of the commercial conditions of manufacture which he was told would be useful, but failed to induce any of those in authority to afford him the information. He finally curtailed his workshop period, and entered a technical college, afterwards becoming a pupil of a Civil Engineer.

Value of Observation. If workshop practice is necessary in order to afford experience in processes and machinery, why should it not be of greater importance that a youth who is intended for the Civil Engineering profession should pass a period of time during his training on railways, waterworks, docks, harbours, road-making, sewerage, sanitary and other works of the kind? It is important to know the properties and uses of materials employed in the execution of works, whether in civil, mechanical, sanitary, or electrical engineering; but a youth will not learn this in a workshop, and he may pass a valuable year of his life in a shop where only one or two special machines, or apparatus of some special kind, are being made. If all training colleges had good workshops attached to them—as is the case in some—a more varied and useful course could be followed in them than is possible in a factory where the youth has to spend his time in a particular shop for a period determined, not by his own need as a learner, but by the work that is going on at the time.

School Work. If the education of a Civil Engineer could be standardised, it would be possible for a properly-established and equipped college to enable a youth to acquire the theoretical and practical instruction which will fit him to take part in actual practice. There are several technical schools which are shaping their course with this aim in view, and there is urgent need of the plan being carried out on a scale commensurate with the importance of the subject from a national standpoint. The necessity for adopting better methods of training than now exist in this country is recognised, and there is a consensus of opinion that other countries are ahead of England in this matter, but the solution of the problem has not received that impartial consideration which it requires. The preliminary school work should be arranged so as to prepare a boy for the advanced theoretical and practical course of a college, well equipped with drawing offices, laboratories, workshops, lecture rooms, etc., to enable the training to be thorough and wide enough to include all that can be taught in the school period and before the youth enters an engineering office as a pupil assistant.

As this Course is intended for the student, it may be useful here to indicate briefly the nature of the works which are embraced in

the practice of a Civil Engineer, in which there will be, for all time, openings for well-trained men in this country and abroad.

Railways. Selection of the route for railways, light railways, tramways. Systems of traction; studying the requirements of the districts to be served by them; surveying and levelling the country to determine the best route for the lines; ascertaining the geological and physical geographical conditions of the country; noting the streams or rivers to be crossed, and the best way to bridge them.

To select the best route involves a knowledge of the use of instruments in the field, and of what route will best serve the commercial conditions of the case, with the best gradients, and the least cost involved in banks, cuttings, tunnels, viaducts, bridges.

Arranging the route by contouring the country, so that the material removed from cuttings balances, as far as possible, that which is required for the embankments. Designing the works to prevent slips in the banks and cuttings. This requires close observation of the strata in which the work is carried out, so that no springs or surface water can collect and produce either a slip or a settlement. Subways. Stations. The maintenance of the railway, its works, permanent way, etc. A resident engineer must be capable of dealing with defects or failures which arise.

Water Supply. Inspecting the district to determine the sources of supply available. Ascertaining the rainfall on the watershed to be utilised and gauging the river from which water is to be taken. The requirements of the community to be served. Constant or intermittent supply. Pumping surface or underground water. Well sinking. Storing water in impounding reservoirs. Selection of site for such reservoirs. Designing and constructing earthwork, masonry, or concrete dams. Calculating stresses. Service reservoirs. Quality of waters. Analyses. Hard and soft water. Softening hard water. Purifying polluted water by filtration or sterilization. Distribution in towns. Flow in pipes and culverts.

Sewerage and Sewage Disposal. Sewering a town on the combined or separate system. Calculating gradients and sizes of sewers. Construction of sewers. Materials to be used and methods of laying sewers according to the sub-soil. Manholes. Lamp-holes. Ventilation and flushing. Admission of trade wastes to sewers. Methods of disposal of sewage. Discharging into the sea, rivers, or estuaries. River pollution. Tidal and other observations necessary. Disposal of sewage on land. Irrigation. Filtration. Suitable and unsuitable soils for these purposes. Chemical precipitation. Sewage sludge. Bacterial treatment of sewage (Aerobic and anaerobic). Management of outfalls.

Surveying. Surveying and levelling. Use of instruments in the field. The Theodolite, Level, Sextant, Box Sextant, Prismatic Compass, Circumferentor, Transit, and Tacheometer. Determining the meridian at a given place. Traverse surveying. Plotting surveys and sections. Drawing office practice. Underground surveying for tunnelling, mining, etc. Hydraulic surveying. Float observations to determine currents. Soundings at sea and in rivers to prepare charts. Gauging rivers and streams. Triangulation. Measurement of base lines. Curvature and refraction. Preliminary surveys. Plane table. Station pointer. *Contouring.* Setting out curves.

Hydraulic Engineering. Docks. Harbours. Sea walls. Groynes. River improvement. Training walls. Reclamation of land. Weirs. Fascines. Dredging. Foreshore protection. Erosion of coasts. Piling. Wharves. Foundations. Underpinning.

Roads. Main roads in town and country. Laying out the best routes. Construction. Foundations. Draining. Wood-paving. Asphalte. Macadam. Stone setts.

Power. Conservation and distribution of power by steam, gas, water, compressed air, and electricity.

Materials and Construction. Cements. Concrete. Proportions and materials for concrete for various purposes. Brickwork. Foundations for buildings and machines. Iron and steel work. Framing. Bridges of wrought iron, steel, or timber. Calculating stresses. Designing structures in iron, steel, concrete, timber, brickwork, etc. Arches. Utilising combinations of concrete with steel and iron.

Machinery. Steam engines. Boilers. Gas works. Gas-producer installation. Pumping engines. Turbines. Waterwheels. Internal combustion engines. Hydraulic engines. Vibrations.

As the ultimate aim of all young men who propose to become Civil Engineers is to become associated with the Institution of Civil Engineers, the rules laid down by that body should be considered as bearing on the course of education that has to be followed by a student. The grades of membership are divided into three, namely, Members, Associate Members, and Students, and it is with the last two that we are now concerned. The Institution holds special examinations for candidates for admission as Associate Members and Students. Exemption is granted in the case of students entering most engineering colleges if the matriculation examination is passed. Exemption is also granted to intending Associate Members if they have passed with Honours the Examinations held by a great many colleges at the end of their courses. A tabulated list of the subjects that the Council of the Institution of Civil Engineers require intending candidates to pass before admission is given at the end of this article. It includes one of the examinations that the Council will accept in lieu of entering for their own, and is one of many other well-recognised degrees that will also suffice.

Examinations. With regard to his admission as a student the Council stipulates that:

1. Where the usual routine of pupilage is being, or has been, served under a corporate member, the pupil may be proposed

as a student at any time after the commencement of such pupilage.

2. Where a course of training at any public institution approved by the council is being, or has been, pursued under a teacher who is a corporate member, the latter may propose a pupil for admission as a student after he has begun a second year of training at such institution.

3. A corporate member may propose for studentship an assistant who has been in his office or works for a period of not less than 3 years.

The Council holds that the special education of a Civil Engineer should in all cases cover a period of two or three years—according to whether the pupil has gone through a college course or not and that this period should in all cases include a course of practical training in or upon engineering works.

SURVEYING

The term surveyor, when associated with the subject of Civil Engineering, differs from the term as understood by the "Surveyors' Institution," the official definition of surveying by that body being "the art of determining the value of all descriptions of landed and house property, and of the various interests therein; the practice of managing and developing estates, and the science of admeasuring and delineating the physical features of the earth, and of measuring and estimating artificers' work."

Practical Knowledge of Instruments. It is intended in this introductory article, and in the subsequent course, to deal with all branches of the surveying profession with the exception of quantity surveying and valuing, which are dealt with elsewhere. The scope of this course may be broadly summarised as embracing Railway, Marine (or hydraulic), Land, and Mining (or underground) Surveying.

It is essential for a young civil engineer to acquire a practical knowledge of the use of the various instruments, and of the several field operations connected with surveying, levelling, etc. Whatever branch of the profession he follows, he will be called upon to do work involving this knowledge, whether the work be on the surface of, or under, the earth, or afloat. He should be well grounded in practical (or applied) mathematics, which will greatly assist him in the solution of the problems that arise in extended trigonometrical surveys, involving the determination of distances, heights, etc., without actual measurement. In this work logarithmic tables are a great help.

In simple surveying operations the Gunter's chain (of 66 ft. or 100 links) is usually employed in this country. Sometimes a 100-feet chain is used. Survey lines are tied together by means of chain angles—as distinguished from instrumental angles. The positions of the various points adjoining the chain line that require to be taken and recorded in the field book, and to be plotted on paper subsequently, are ascertained by measurements made with an "offset staff," 10 links long, taken at right angles to the chain line. Setting out these lines, by ranging them truly, is essential. The distance that the offsets can be taken accurately is limited, as the direction of the several offset lengths at right angles to the chain line is determined by the eye. The arrangement of the links to make a chain survey of this description requires skill, in order to complete the survey, and to include every object, with the minimum number of chain lines. If the ground is hilly "double ranging" must be resorted to.

Levelling. When it is necessary to take offsets of some distance from the chain line various forms of instruments can be employed, such as the cross, box sextant, and optical square, which enable a right angle to be set out with accuracy. In the event of the survey being carried out by angular measurements, the theodolite is the usual instrument employed. For smaller works, and for filling in details, the prismatic compass is used.

In the office it is frequently necessary to make reductions of plans that have already been plotted to a large scale. These reductions can be done by the method of "squares," or more rapidly with the use of the eidograph and pantagraph. It is also very often required to take out the areas of various portions of a survey, and the instrument generally used for this purpose is the planimeter. Setting out curves with the chain alone, or with the chain and theodolite, will be described in detail in the course. When it becomes necessary to determine the relative positions with regard to vertical height between points on a Survey, the level is used. In order to be able to plot these points (to make a section of the ground), it is usual to chain between them, and take readings with the level on a level staff at the several chain points, the distance and readings of heights being entered in a level book to enable them to be plotted to scale on paper. The level staff is 14 ft. long, graduated to feet and tenths of a foot. In the event of its being necessary to ascertain the level of the ground on either side of these lines, it is necessary to take what is known as cross sections. These are taken at points where there is any considerable variation in level of the ground there, and at right angles to, and on each side of, the chain line. In this country the Ordnance Department have established Bench Marks (called B.M's), and their values are recorded, the figures representing the height of the points above mean tide at Liverpool, which is the standard datum.

Ordnance Survey. Starting from one of these known points, the levels of any other points may therefore be established with regard to this datum. By laying down a datum horizontal line on the paper, representing any convenient height above the standard datum, and by drawing lines perpendicular to it at the various chain points, the relative levels of the various points on the section may be plotted to scale, and the line joining these points is the actual surface of the ground.

The Ordnance Survey greatly facilitates surveying work, and often the only field-work that is required consists in the filling in of details or alterations of lines, etc., that have been carried out since the Ordnance Survey was last corrected. In cases, however, where large surveys have to be carried out the theodolite is employed for triangulation by taking the angles between long lines, or by "traversing," which means taking the magnetic "bearings" of the lines by the needle of the theodolite or prismatic compass.

The beginning of all large surveys is by measuring a base line with a chain most accurately, the several chain lengths being taken with the chain perfectly horizontal. A better way is to use bars for the measurement of these lines, and these must be compared at times with standard bars, in order to check their accuracy. From this base line will be constructed a system of triangulation to enclose all objects necessary to complete the survey. In mountainous districts the sides of the triangle may be very considerable, as the theodolite readings can be taken to stations many miles apart. All these base lines have to be reduced to sea-level, so that it is necessary to ascertain their relative levels.

Stations for Small Surveys. The positions of stations for small surveys can be fixed by means of the theodolite and chain, and their vertical differences of height by means of the level. For extended surveys they have to be determined by the tacheometer and omnimeter. The aneroid barometer can be employed for rapidly ascertaining differences in height, care being taken to note variations of barometric pressure. The ordinary barometer can also be used by applying a formula to convert inches, or fractions of an inch, into feet. The hypsometer is another instrument used to ascertain differences in height by recording the boiling-point of water at the respective stations. In recent years the tacheometer has come into prominence, and by means of this instrument the vertical and horizontal distances in rough countries can be determined with great accuracy and rapidity.

A method of carrying out surveys that was largely employed in America, and is now utilised generally, is that of the Plane Table, by means of which the map is sketched in on the ground as the survey proceeds. For the mapping of new countries, and the surveying of routes for railways, the surveyor must be able to locate his position by finding the latitude and longitude of the place. It will therefore be necessary for him to have a certain knowledge of elementary astronomy. A knowledge of mensuration is also essential in order to be able to compute areas and take out quantities.

Mining and Marine Surveying. The chief differences in mining and land surveying are in respect of that portion which has to be accomplished below the earth's surface, in order to locate the direction of the various headings and tunnels. The "Circumferenter" or "Miner's Dial," is largely used in this work, and the directions of the various headings are ascertained by taking the "magnetic bearings" of the lines with the Miner's Dial, and by chaining their lengths, the lines being afterwards plotted in the ordinary way. It will be explained how the "variation" of the magnetic needle has to be taken into account to prevent the mistakes which have often happened in laying down new observations on an old survey without making due calculation for variation.

Hydrographical, or marine, surveying has for its object the preparation of plans and charts to indicate the positions of shoals and bars, either for navigating purposes or for civil engineering operations. The surveying of foreshores and rivers by the Admiralty is recorded on charts, the position of subaqueous ground being indicated in fathoms (or six feet units). The civil engineer has, however, frequently to supplement the official charts by detailed observations in some locality for special purposes in connection with contemplated works. He has to take float observations to determine currents and the direction of tides for many purposes in his practice. The Sextant and Station Pointer are used when the observer is afloat, and the Theodolite when he is on shore taking readings to stations afloat, either fixed buoys, drifting floats, or any assistant in a boat taking soundings by signal at the instant the position of the boat is fixed by the observations made on shore. This kind of surveying is constantly called into requisition in connection with harbour and dock works, foreshore protection and the erosion (or removal of material) along coasts. It is essential to be familiar with it where sewage outfalls discharge into the sea or tidal estuaries, so that full knowledge is obtained as to what will become of the sewage before public money is spent in so disposing of it.

Railway Surveying. This branch of survey work resolves itself into two main features, that of the survey for the preliminary route and the final setting out of the work. The main features which govern the selection of the route are the grades and the curves, and have to be adapted to the general outline of the locality through which the line has to pass. In selecting a route, the surveyor must endeavour to arrange so that the excavation and embankments as nearly as possible equalise one another, to avoid having to "run to spoil" surplus excavation. The curves are usually set out with the theodolite and chain or by the chain alone. Many instruments have been invented for setting out curves, especially in flat country. Cross-sections have to be taken all along the centre line, so that the quantity of embankment or cutting can be calculated. Where the line is in tunnel it is usual to set the direction out on the surface of the ground and to sink shafts on the line at various points. The position of the station at the surface is then transferred to the bottom of the shaft, by means of a theodolite on the surface, and then produced underground, the level of the line at each shaft being accurately calculated and plumbed.

To be continued

SCHEDULE OF EXAMINATIONS FOR CIVIL ENGINEERS

(For Qualifications for Candidature, see Text)

Examining Body, Grades, Time, and Place of Examinations.	Subjects of Examinations — Obligatory.	Subjects of Examinations — Alternative or Optional.	Fees and Age Limits.
INSTITUTION OF CIVIL ENGINEERS. Students. London, Feb. and Oct. or at Manchester, Glasgow, Newcastle-on-Tyne in Feb.	**English.** A general Paper comprising questions in Geography, History and Literature. **Mathematics.** Arithmetic, Algebra. Geometry (Euclid I.-IV.). Trigonometry (up to and including the solution of triangles).	Two subjects, to be selected by the Candidate from the following ten: a language is not compulsory, but in any case not more than one language may be taken. **Latin, Greek, French, German, Italian, Spanish.** **Elementary Mechanics** of solids and fluids. **Elementary Physics,** including heat, light, electricity and magnetism. **Elementary Chemistry,** including the principal properties of matter, the laws of chemical affinity, atomic weights, valency, and the chemistry of the principal inorganic elements. **Geometrical and Freehand Drawing,** including projective and descriptive geometry and perspective.	£1 1 0 18–25
Associate Member. London February and October.	**Part I.—General Knowledge.** Candidates are required to prove their knowledge of the English language and their attainments in general knowledge by writing an essay of about 1,000 words upon one of certain set subjects. Persons who are, or who have been, Students of the Institution, or who produce such qualifications as would, under the existing Regulations, exempt from the examination applying to admission of Students are not required to pass Part I. of this Examination. **Part II.—Scientific Knowledge.** Applied Mechanics, Strength and Elasticity of Materials.	**Part II.—Scientific Knowledge.** Theory of Structures or Theory of Electricity and Magnetism. Two of the following nine subjects—not more than one from any group. **Group I.** Geodesy. Theory of Heat Engines. Metallurgy. **Group II.** Hydraulics. Theory of Machines. Thermo- and Electro-Chemistry. **Group III.** Geology and Mineralogy. Stability and Resistance of Ships. Applications of Electricity. **Mathematics.** The standard required for Part II. of the examination is that of the mathematical portion of the Examination for Admission of Students, though questions may be set in higher Mathematics.	£2 2 0 21 and upwards

UNIVERSITY QUALIFICATIONS WHICH SECURE EXEMPTION FROM THE ABOVE EXAMINATIONS

UNIVERSITY OF LONDON. B.Sc. (Engineering).

CAMBRIDGE. B.A. (Mechanical Science Tripos).

ST. ANDREWS. B.Sc. (Engineering).

GLASGOW. B.Sc. (Engineering).

EDINBURGH. B.Sc. (Engineering).

VICTORIA UNIVERSITY OF MANCHESTER. B.Sc. (with honours in Engineering).

LIVERPOOL. B.Eng., provided the degree be obtained by passing the Examinations of the University.

LEEDS. B.Sc. (with honours in Engineering).

BIRMINGHAM. B.Sc. (Engineering), provided the Engineering Matriculation Examination be passed on entering upon the course of study.

DUBLIN. B.A.I.

ROYAL UNIVERSITY OF IRELAND. B.E. and M.E.

UNIVERSITY OF WALES. B.Sc. (Engineering); provided Mathematics be passed at Final Examination for the degree.

MCGILL UNIVERSITY, MONTREAL. B.Sc. (in the Department of "Civil," "Mechanical," "Electrical," or "Mining Engineering) provided that Geography and either Chemistry or Physics be passed at the Matriculation Examination.

SCHEDULE OF SURVEYORS' INSTITUTION EXAMINATIONS

Preliminary. London, Dublin, Manchester, Glasgow. January.	Elements of Algebra, Euclid (first three books), English History, Composition and Writing from Dictation. One of three languages: Latin, French or German.	None.	£1 1 0 18–21
*Intermediate For Professional Associateship. London, Glasgow, and Dublin. March.	*Farm Buildings, Land Drainage, Geology and Soils, Chemistry, Bookkeeping, Law of Landlord and Tenant, Mensuration, Law of Fixtures, Dilapidations, Easements, and Riparian Rights, Application and Use of Valuation Tables, Copyholds, Drainage and Sanitation, Surveying, Levelling, and Elements of Trigonometry, Bills of Quantities, Constructive and Working Drawings, Composition and Properties of Stones and Cements.	None.	£3 3 0 (over 21)
*Final for Fellowship. London, Glasgow, and Dublin. March.	*Botany, Agricultural Chemistry, Valuations and Law, Forestry, Timber Valuing and Measuring, Local Taxation, Valuation, Law of Arbitration, Enfranchisement of Copyholds, Acts for Compulsory Purchase of Property, Law of Vendors and Purchasers, Quantities, Constructive and Working Drawings, Drainage and Sanitation, Iron and Timber Roofs, Specifications of Building, Report.	London Building Acts or Public Health Acts. Two of the following—Algebra, Animal Physiology, Development of Building Estates, Hydrostatics, Principles of Parochial Assessment, Road Making, Mechanics (Law of Forces).	£3 3 0 (over 22)
*Direct Fellowship. London, Glasgow, and Dublin. March.	*Same as Intermediate, except Bookkeeping and Surveying, with these additional in their respective subdivisions: Enfranchisement of Copyholds, Acts for Compulsory Purchase of Property, Development of Building Estates, Specifications of Building, Iron and Timber Roofs, Report.	London Building Acts or Public Health and Local Government Acts.	£3 3 0 (over 30, & must have practised on own account more than 5 years)

* Divided into three Sub-Divisions.—I. Chiefly Land Agency; II. Chiefly Valuations; III. Chiefly Building or chiefly Quantities.

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THE CHOICE OF A PROFESSION

THREE considerations should guide the choosing of a career—the taste and temperament of the individual, the cost of preparation and instruction, and the probable rewards. The first part of the SELF-EDUCATOR contains a table of shopkeeping careers; the details which follow will guide young people and their parents in the choice of a profession.

Accountants. The candidate must pass a preliminary examination or show qualification entitling him to exemption, and serve five years indentured apprenticeship with a chartered accountant, who usually exacts a premium of from 100 to 500 guineas, part or all of which may be returned in salary. University graduates serve only three years in England, four years in Scotland. An intermediate and final examination must be passed. Most chartered accountants in business make handsome incomes, often anywhere between £1,000 and £20,000, but qualified employees are not usually paid in proportion to the fees charged for their services. There are several other bodies of public accountants with different membership qualifications, but without the prestige of the chartered accountant.

Architects and Surveyors. A course of two years at an Architectural School in London or the provinces – average fees £40 a year – is probably the best preliminary training, but a youth may enter the profession as articled pupil, improver, or assistant. A pupil is generally articled for three or four years, or if he has had preliminary training, for two years; usual fee 100 guineas, although 300 guineas is sometimes required. Preliminary examination of Royal Institute of British Architects is almost essential before apprenticeship. Three examinations are required before the title of Associate R.I.B.A. is obtained. Fees for examination, £9 9s. Improvers' salaries, about £50; junior assistants and draughtsmen, 30s. to £2 10s. per week; managing assistants, £3 3s to £5 5s. An architect's principal remuneration is 5 per cent on the value of works erected, or 10 per cent if buildings are small. Special charges are made for valuation. The salary of the architect to large trading companies or local authorities is from £500 to £700 per annum; assistant surveyor employed by local authority, £200 to £300. Average salary of a surveyor ranges from £500 to £600. Some technical Civil Service competitions are open to men trained in architects' or surveyors' offices, with salaries ranging from £150 to £700.

Army. Private means essential in this profession, £70 to £80 minimum for the first few years, and £50 afterwards. This will cover expenses only and not permit extravagance. Boy should be at a public school where pupils are prepared for Army, or may be sent to an Army coach. For the Infantry and Cavalry, he usually passes through Sandhurst (limit of age, 19, with two examinations). For Engineers or Artillery the cadet is trained at Woolwich (age for admission, 16 to 18). He may go through the Militia for any branch of the service. The regiment chosen should depend on the fortune at command. The Household Troops are the most expensive, then the Cavalry and the Infantry. The Indian Staff Corps officer receives quite three times the pay of his brother officer in England, and can live comfortably on his salary. The West India Regiment is a good one where economy is necessary.

Auctioneers. Usual indentured apprenticeship is three years, premium up to £100. Small salary, beginning at 5s. weekly, during apprenticeship. Assistant frequently begins at 20s. a week, plus commission on business he introduces. The two principal classes of auctioneers are property auctioneers and agricultural auctioneers. The former demands the greater ability. The two are often combined. A ready wit, a pleasant manner, and intimate knowledge of his business are essentials to a successful auctioneer. The profession is one where the right man makes money rapidly. A modest start may be made on £200. An auctioneer's licence costs £10 annually, and full gold and silver plate license £5 15s.

Bankers. Bank clerks usually begin as apprentices after showing certain educational qualifications, and serve three or four years, receiving from £10 to £40 a year to begin. In large city banks, director's nomination is usually necessary. Some London banks take apprentices at £60 or even £80. The work of the bank clerk is becoming more and more systematised into mechanical routine. Promotion is usually by £5 or £10 a year, until the salary reaches from £250 to £300. Cashiers, accountants, and managers get more. Many banks forbid marriage unless upon an income of £150 to £200. The Bankers' Institute affords opportunity of studying banking law and practice. The chief recommendation of the profession is that, although the average remuneration is modest, positions are practically secure for life, and pensions follow retirement.

Chemists. Apprenticeship of three to four years with registered chemist and druggist, during or prior to which the preliminary examination should be passed. Some certificates exempt. Minor examination of Pharmaceutical Society (fee £10 10s.) gives the legal title "Chemist and Druggist"; a higher examination, the Major (fee £5 5s.), gives the title "Pharmaceutical Chemist," and exempts from juries. In Ireland the examinations of the Pharmaceutical Society of Ireland must be taken.

Analytic chemists graduate from universities, technical schools, and pharmacies. The most useful degree is Fellowship of Institute of Chemistry, almost essential for appointments as public analysts, who are highly paid. Independently, a man may make his mark in special analyses, such as oils, fats, drugs, etc., and become recognised expert. The B.Sc. (London) is valuable, fee £5, but Matriculation Examination

[illegible] the [illegible] must first be passed. Expense of setting up as analyst not heavy, say £300 to £500. [illegible] ability, good luck, or influential [illegible] necessary to get beyond the usual £200 or £300 annual income.

Church. Candidates for the Established Church must hold a University degree or have passed certain examinations during residence at one of the Theological Colleges. An increasing number of men are now ordained without university qualification. The total expense of a three years' course at a church college (including board, tuition, and college charges) is usually £100 to £160 per annum, but Keble College, Oxford, exacts only £81 a year. The expenses of a non-collegiate student are, of course, less. At Dublin and Durham the course is only two years. Many livings are worth less than £50 a year, and a large proportion are under £100. Junior curates earn from £80 to £140 a year, and senior curates up to £200. The average country living is worth £200 to £400. In the Army and Navy chaplaincies yield pensions on retirement.

In the Congregationalist Church the course of study is usually five years, and students contribute about £80 a year towards their maintenance during the course.

Students for the Wesleyan ministry are selected by the circuit quarterly meeting and confirmed by Synod. They attend three years at a theological institute, and are expected to pay £50 to £70 a year. For poor students the fees are remitted.

The training for the Baptist ministry usually lasts four years, and students are expected to pay for their support and training if they can afford it.

The Presbyterian ministry involves a training of three to five years. A University Arts degree is practically essential as a preliminary qualification. Each year of the theological course is divided into three terms, and the terminal charge of £15 per term covers residence, board and tuition. By winning scholarships a student may work his way through a theological college without personal outlay.

Dentistry. Three years must be passed in mechanical dentistry under a qualified practitioner, either in private practice or in a hospital. Premiums for apprenticeship in private practice range from 50 to 150 guineas. At the London dental hospitals and colleges the *composition fee* of £160 includes three years' mechanical pupilage and two years' hospital practice and lectures. Dental students pass same preliminary examination as medical students and must register as dental students. By making mechanical practice and study run concurrently the course of dentistry may be condensed into four years. The degree of Licentiate in Dental Surgery is granted by Examination Board of Royal College of Surgeons. The Scottish and Irish diplomas are cheaper and easier to obtain than the English degree. Various degrees are given by recognised dental hospitals and schools.

[illegible] A good [illegible] higher [illegible] machine, [illegible], and freehand drawing, should be [illegible] basis of an engineer's education. An engineering course at a university college lasts three years' and fees vary from £60 to £170. During the first two years of training the instruction is similar for whatever variety of engineer is in the making. The railway companies take apprentices usually for five years at a premium of from £16 to £25, and give small wages during the term. Many private firms demand premiums of £300 for articled pupils. The best course is to study for a year at a technical college near the works of a good engineering firm, afterwards becoming apprenticed and continuing study. The cost of this course is from £300 to £500, including premiums. The cost of training can often be reduced by scholarships. In the three main branches of engineering—civil, mechanical, and electrical—prospects are fairly good all over the world, and the expenses of technical training are much the same in each. The highest paid posts are in gold mining engineering, where salaries occasionally rise to £10,000 a year. The rank and file of the profession is usually recruited from "unpremiumed" apprentices who, during their five years of service, earn from 2*s* 6*d* to 10*s* a week. Hard study and application often bring the prizes of the profession within their grasp.

Insurance. Conditions and salaries at the beginning are much the same as in banks. The posts for senior clerks are not so numerous as in banking, and the maximum salary is not so high. There are however, many good positions, such as inspectorships and branch managerships, to which a clerk with a capacity for pushing outside business may aspire. Branch managers make from £300 to £1,000, or even more. A young man with mathematical ability may pass the examinations and become an actuary, which will enable him to rise more quickly in the life department.

Journalism. Journalism, if it offers great rewards to those who succeed in it, demands great mental vigilance and physical endurance. The prizes of journalism will go more and more in the future to those who begin at the bottom of the ladder. Shorthand, typewriting, a sound knowledge of history, literature, and grammar; a working knowledge of French, with German if possible; an intelligent appreciation of public affairs, with a special interest in, say, European or American politics; some practical knowledge of printing conditions; observation, concentration, lucidity in expression—all these are factors in the making of the journalist. The boy should begin, for preference, in the reading room of a newspaper office, then becoming a junior reporter, either by apprenticeship or without it. As an apprentice he may be paid from 5*s*. to 10*s*. a week on a provincial paper, where training is easier to get than in London. Reporters may earn from £2 to £5 a week or even more in the provinces, or from £3 to £8 in London. Every journalist should have some experience in sub-editing,

which [illegible] the same [illegible] as reporting. [illegible] as a career is [illegible] and only those who can face the varying fortunes cheerfully should enter upon it. It is likely to be more strenuous and [illegible] still, but the journalist with character, initiative, and a serious interest in his work will not be disappointed.

Law. The legal profession is much overcrowded. Years of waiting may be necessary before business comes, and the would-be barrister should have capital. There are four Inns of Court—Lincoln's Inn, Middle Temple, Inner Temple and Gray's Inn. Preliminary examination is necessary, but numerous university qualifications entitle to exemption. Students must "attend twelve terms," which means a minimum period of three years—*i.e.*, they must eat a specified number of dinners. The fees paid in Gray's Inn are the least expensive—on the student's admission, £39 13*s.* 6*d.*; and on his call to the bar, £89 2*s.* 4*d.* Additional charges are the dinners, coaching with a barrister—which is usual, but not compulsory—and the living expenses during the years of study. The law does not yield enormous incomes except to those at the top. The average legal income of qualified barristers is less than £50 a year.

The youth who would be a solicitor must pass a preliminary entrance examination—from which, however, certain university diplomas entitle to exemption. Apprenticeship is for five years, except for London University undergraduates, who serve four years, and graduates of London, Oxford, and Cambridge, who serve only three years. Usual premiums for apprenticeship £100 to £300, with stamp duty, £80. For intermediate and final examinations the fees are £3 and £5 respectively. An independent start as a solicitor should only be attempted if there is capital or a secure small income at command. An ordinary country solicitor should earn from £500 to £800 a year.

Medicine. Students must pass a preliminary examination, unless they hold University certificates exempting them. The minimum length of study is five years, and class, hospital, and examination fees reach £100 to £200. A student may, with economy and hard work, go through a medical course for £400 at some universities. Poor men should utilise the medical schools where bursaries are numerous. There are many congenial openings for the medical man. Medical officers on the chief ocean liners earn £120 to £150 a year; resident prison and asylum doctors, £200 to £500; and non-residents, £50 to £250, the latter being allowed private practice. Police surgeons are paid usually 5*s.* per man attended. Poor law medical officers receive £20 to £200. Medical officers of health average £400 to £500 for whole-time officers. Other posts yielding regular incomes are those of consulting medical officers to insurance companies and government departments, and medical inspectors of ships. Army surgeons begin at £200 per annum, and navy surgeons at £209. The largest incomes in private practice are earned by specialists.

[illegible] In Veterinary [illegible] Council or [illegible] Preliminary [illegible] of the [illegible] Institute of Scotland. Then, during four years' study, he must pass four professional examinations. Examination and registration fees reach £21. Fees at the Royal Veterinary College, London, aggregate £90, paid in four instalments. In the Royal (Dick) Veterinary College, Edinburgh, matriculation and class fees are only £58 16*s.* Veterinary surgery offers good prospects to young men fond of outdoor life and animals.

Musicians. Exceptional talent is necessary to reach eminence in the musical profession. The musician should begin early. Many of our prominent musicians were distinguished as children, and there can be no doubt that early training "tells" in music more than in most other professions. Private tuition ranges from 20*s.* for twelve lessons to any fee the teacher can command. The Royal Academy of Music in London charges five guineas entrance fee and 33 guineas annually, payable 11 guineas per term, but as there are many scholarships, clever pupils often complete their curriculum almost free of cost. At least one year must be passed in study. The Royal College of Music gives three years' instruction at 12 guineas per term. These colleges and several universities give degrees in music. The biggest school of music in the world is the Guildhall School in John Carpenter Street, London. The chief provincial schools are Royal Manchester College of Music, and Royal Irish Academy of Music (Dublin). In the Paris Conservatoire education is free, but entry is possible only by examination. Students at Leipzig Conservatoire study for three years, except where able to join the advanced classes at once. Expense, including board, lodging, and fees, is usually reckoned at £90 a year. Ordinary church organists earn from £20 to £100 a year, but usually have the right to teach upon the church instrument. Private engagements are profitable, evening "At Homes" yielding from 10*s.* 6*d.* to 2 guineas up to £60 or £100. Orchestral engagements yield from 45*s.* to 5 guineas per week. For other music, common rates are 25*s.* to 42*s.* for bandsmen, and 30*s.* to 50*s.* for principals.

Navy. Naval cadets must pass entrance examination (fee 10*s.*) between 13 and 14½ years of age, after having obtained nomination from First Lord of Admiralty. Examinations are held half-yearly—June and December—in London. Two years' service on the "Britannia," costing £100 a year inclusive, follow the passing of this examination, and there is an examination at the end of each term. Then the boy is a midshipman, and rises, if following the executive side, through the grades of sub-lieutenant, lieutenant, commander, captain, and perhaps to rear-admiral, vice-admiral, admiral, and Admiral of the Fleet. Other branches of the Service are the engineering, medical, paymasters, and Royal Marines. The naval officer may follow his profession without the private means necessary for an army officer.

Painting and Sculpture. The artistic temperament, the perception of the beautiful and the ability to express it, alone justify the adoption of art as a career. Both day and evening instruction is given at the art schools. The chief London school is the Royal College of Art, South Kensington, where fees range from 5*s.* to £5 per term, and under certain conditions students are admitted free. In South Kensington comfortable board and lodging may be had for £60 per annum. The Royal Academy schools are difficult to enter. Competition for studentship is keen, and more than moderate ability is required to secure admission. Instruction, limited to three years, is free. The age limit for painters is twenty-three and for sculptors and architects, twenty-five. Other art schools include the Polytechnic Institution, City of London College, and the Birkbeck, Camden, and Lambeth Schools of Art. In all of these day tuition costs a few guineas per term, and evening tuition a few shillings. At London University College, in Gower Street, fees are from 3 to 15 guineas for nine months; at Royal Female School of Art £1 to 13 guineas, and at Herkomer School of Art, Bushey, Herts, 18 guineas. There are numerous provincial schools of art, such as those in Liverpool, Manchester, Birmingham, Nottingham, Sheffield, and Glasgow. Study abroad is less costly than study in Great Britain. In Julien's Academy, in Paris, fees are from £1 to £2 per month, and the total cost of living and study in Paris need not exceed £7 or £8 per month, and may well be less. Students in Antwerp often get along on £1 per week. The chief fields for the artist are in painting, in black-and-white work for newspapers and magazines, and in teaching.

Sanitary Inspectors. The profession is best entered after passing the examination of the Sanitary Institute; fee, 4 guineas; expenses of coach usually 5 guineas. Whole time officers receive £100 to £250 a year, and occasionally more.

Stage. The stage is the most heart-breaking of professions. Preliminary training may begin in the elocution class of a local institution, with membership in an amateur dramatic society. Deportment, elocution, and dramatic action are taught at London School of Music and Royal College of Music. There are several dramatic academies in London, a course of lessons costing 4 to 12 guineas. Male "supers" are paid 1*s.* 6*d.* to 2*s.* 6*d.* a night, rising to 30*s.* a week. In London they are usually soldiers from the barracks or reservists. Ladies employed to "walk on" receive 20*s.* a week. In London, ladies of good social position are preferred. For a speaking part £2 to £3 a week is paid; for moderate talent, £3 to £5 a week; and for stars up to £60 a week. Those who rise higher are the very few exceptions.

In "musical" theatres the voice trial must be passed, and 35*s.* a week is an average salary to begin.

Salaries differ much in travelling companies.

Stockbroking. No indenturing and no premiums. A youth usually passes four years as house clerk without salary. In the Stock Exchange (*i.e.*, in London), which the provincial exchanges follow, a new rule stipulates that two years as house clerk and two years as settling room clerk may constitute qualification for membership. After four years' service in the House, a clerk may become a member by committee nomination or by purchasing a nomination (price £100–£120) if he acquires at same time one Stock Exchange share (value about £230). Employes frequently earn only £80 a year salary, but by commissions on business introduced to their employers often aggregate handsome incomes. Capital is essential to beginning business of stockbroker, as much business is financing. Practically no limit to possible income of successful stockbroker. Some London brokers earn not less than £50,000 a year. The physical and nervous strain of the work is very great.

Teaching. The teacher in an elementary public school usually begins as a pupil-teacher at sixteen. Apprenticeship lasts four years, and includes part-time teaching. Boys receive 5*s.* to 12*s.* per week; girls, 3*s.* to 8*s.* a week during pupil-teachership. Examinations are held during the apprenticeship. The King's Scholarship examination must follow immediately on completion of pupil-teachership or later. Two or three years in a training college usually follows. Tuition and lodging cost £25 to £30 for the two years, but not less than £5 a year is necessary for books and other expenses. After passing from college, and after eighteen months' probation in an elementary school, the teacher receives his *parchment*, and is *trained*. The assistant master in a public elementary school in the provinces begins at about £85, and rises to £150. In London the minimum is £95 and the teacher can rise to £200. Teachers in Church Schools receive much smaller salaries, the average being only about £70. Public elementary school male teachers average £130; women average £80. Salaries of headmasters in London Schools vary from £175 to £400; those of infants' and girls' headmistresses between £140 and £240 or £300. Provincial salaries are on a somewhat lower scale. Under London County Council scale an untrained teacher can commence at £90 and go up to £160. In the provinces an untrained teacher's salary is about £20 or £30 less than a trained teacher's. Uncertificated teachers are not now appointed under the London County Council, but are numerous in the provinces.

In Secondary Schools a university degree is necessary, and the highest appointments are usually given to Oxford or Cambridge graduates. Assistants in secondary schools earn from £100 to £700, the average being from £200 to £350. The headmasters of the chief schools, such as Eton, Winchester, Harrow, and Rugby, receive from £3,000 to £8,000 a year with residence. In others, like the City of London, the salary is from £1,000 to £2,000.

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THE PLAN OF THE VEGETABLE KINGDOM

The Wonderful Scheme of Nature. Kingdoms and Sub-Kingdoms of the Vegetable World. Scientific Grouping of Flowers and Plants

By Professor J. R. AINSWORTH DAVIS

IT forms no part of the plan of this course to give elaborate details regarding the classification of plants, and students who wish to find out the names of common forms are advised to consult the ordinary systematic treatises. We must, however, even at the outset, acquaint ourselves with the main subdivisions of the vegetable kingdom, beginning with the highest, as these will form convenient headings under which the facts to be considered may be arranged in an orderly fashion.

Each of the largest subdivisions is termed a *phylum* (or *sub-kingdom*), the further subdivisions being *sub-phylum*, *class*, *order*, *sub-order*, *genus*, and *species*. With the last five we are not at present concerned. It is also convenient to use the word *group* in rather a loose sense, where plants that are not necessarily closely related are associated for some special reason, facilitating their study.

PHYLUM 1. FLOWERING PLANTS

[*Phanerogams* or *Spermaphytes*].

This phylum includes the great bulk of familiar plants, whether trees, shrubs, or herbs. They all possess *flowers*, which are commonly, though by no means always, conspicuous. These may broadly be considered as special arrangements which have to do with the production of seeds, and a *seed* is a reproductive structure containing a dormant plantlet, which under favourable circumstances is able to grow into a new plant. The seed is, so to speak, a special device for tiding over the unfavourable season of the year. The plants of this *phylum* are provided with roots, stems, and leaves, all of which are *vascular*, *i.e.* they are traversed by tough strands (aggregated into vascular bundles), which serve as a supporting internal skeleton, and also conduct sap. The so-called "veins" of a leaf are good examples of such bundles, and the stringiness of old beans is due to their presence in an unwelcome degree.

Sub-Phylum 1. Pod-plants [*Angiosperms*]. The large majority of Seed-plants belong to this subdivision, in which the seeds are protected by being enclosed in some sort of case, such as the pod of a pea or broom [18],* or the large hard capsule of a poppy, such as may be seen in any chemist's shop. Other examples are afforded by the seeds (pips) of an apple or orange.

Sub-Phylum 2. Naked-seed Plants [*Gymnosperms*]. Though sufficiently well protected, the seeds are not here enclosed in a special case. Of this we may be convinced by pulling to pieces the cone of a fir [16], pine, or larch, when a couple of seeds will be discovered on the upper side of each scale.

* For Figures 1 to 18 see coloured frontispiece.

As a matter of convenience all the remaining phyla may be collectively spoken of as constituting the great group of *Flowerless Plants* (*Cryptogams*), *Seedless Plants*, or *Spore Plants* (*Sporophyta*), as they have been at various times called. The second name, however, is the only one of the three which is not open to grave objections, as we shall subsequently see, though it is most usual to speak of *Cryptogams*, and there is no harm in using the word as a mere label. Neither conspicuous coloured flowers nor seeds are present, and the typical means of propagation is by means of spores. Everyone must have noticed brown patches on the backs of fern-fronds, and if these are examined under the microscope it will be found that they are made up of little cases filled with minute grains [13]. These are the *spores* which are able, under favourable conditions, to produce fresh plants.

PHYLUM 2. FERNLIKE PLANTS

[*Pteridophytes*].

The Fernlike plants or Vascular Cryptogams, of which Phylum 2 consists, are the highest Cryptogams, which agree with seed-plants in the possession of roots, stems, and leaves, traversed by vascular bundles. Ferns of all kinds are the most obvious examples of the phylum [13], which also includes the club-mosses of mountain and moorland, the horsetails of swampy ground [14], and certain other plants.

PHYLUM 3. MOSSES, LIVERWORTS

[*Bryophytes*].

Neither roots nor vascular bundles are present. The familiar mosses [12], though capable of surviving a large amount of desiccation, only thrive in damp places or during the wetter parts of the year, and their lowly relatives, the *Liverworts* [11], are for the most part markedly moisture-loving plants. In some of these there is no division into stem and leaf, the plant-body being a flat green expansion or *thallus*. Liver-worts may often be noticed on damp earth in early spring, in shady corners near brooks or waterfalls, or covering the damp crannies of wet hedge-banks with their sheets of green.

PHYLUM 4. PRIMITIVE PLANTS

[*Thallophytes*].

Here is included a vast assemblage of lowly forms, some conspicuous, but many microscopic, in which the plant-body is a thallus of various shape; a group widely distributed all over the globe, from the surface of the polar snows to the gloomy abysses of the sea. This Phylum divides itself into three groups.

Group 1. Algae. Like all the plants above them in the scale, these forms contain a

very characteristic green pigment (*chlorophyll*), which renders it possible for food of very simple character to be built up into complex compounds, which furnish the material for the renewal and growth of protoplasm. Most of these lowly plants are aquatic. They include the green sea-weeds [6], flat or threadlike, which abound in tide-pools on the sea-shore, and their fresh-water allies that are often to be seen as a green scum or as masses of slimy threads in stagnant ponds. The powdery green investment on the trunks of trees or wooden palings, or even in roof-gutters, consists of microscopic green *Algæ*, which are also abundant in marine or fresh-water mud. These last belong to a special class (*Desmids*), characterized by their elegant shape and often by their powers of movement [5].

Though *algæ* always contain *chlorophyll*, it is often obscured by the presence of pigment of some other colour, as in the brown sea-weeds, which cover the "between-tide" rocks, or make up huge floating masses in certain parts of the ocean (*gulf-weed*). We have also the beautiful red sea-weeds cast up by storms upon the shore [6].

From the artistic standpoint, by far the most attractive *algæ* are the microscopic *Diatoms* [4], which swarm in the sea and in fresh water, and are of the most varied shapes. They possess a flinty skeleton, often sculptured with regular geometrical patterns of the most intricate and beautiful kind, which reveal fresh marvels as they are viewed with successively higher powers of the microscope. Many a would-be scientific amateur, fascinated by their charm, has ended by becoming a hopeless "diatomaniac."

Group 2. Fungi. The plants so far considered all contain *chlorophyll*, and this is only able to exercise its peculiar function in the presence of light. But as *fungi* are devoid of this colouring matter, they are quite independent of light, and hosts of them live and thrive in perfectly dark places, feeding during the night as well as throughout the day. We may say, in fact, that these plants are adapted to occupy places that would otherwise be devoid of plant-life altogether. To this power there is, however, as a general rule, one drawback, *i.e.*, the food must be of a more complex nature than that of green plants, and we find that fungi are in ordinary cases dependent upon the organic matter formed by the death and decay of other organisms, or else that they prey upon the living bodies of these. In the former case they are known as *saprophytes*, in the latter as *parasites*.

Mushrooms and Toadstools [7, 8]. These are the most conspicuous and perhaps therefore the most familiar fungi. What we call a *mushroom* consists of innumerable microscopic threads compacted into a stalk bearing a rounded expansion, on the under side of which are a number of radiating pink or brown plates known as *gills*. If the top of a mature mushroom is placed on a sheet of white paper, left for some time, and then lifted up, we shall find on the paper a coloured radiating pattern following the arrangement of the gills to the most minute detail, and inspection shows that the pattern is traced in a sort of impalpable dust. This dust consists of an infinite number of *spores*, which have fallen from the gills, and the so-called mushroom is simply a spore-producing arrangement. The actual plant-body of the fungus is in the form of a branching mass of whitish threads which run through the underlying soil, making up what the gardener knows as *spawn*.

Moulds, Mildews, etc. Food, leather, and many other things, if kept in damp places which are warm and dark, are apt to become "mouldy" or *mildewed* owing to the growth of various fungi. One of the commonest forms of these is "green mould" [3], such as may often be seen on damaged oranges, while "blue mould" attacks some kinds of cheese. In either case the plant-body is a mass of branching threads, from which special spore-bearing branches rise up into the air. Many diseases of crops—*e.g.* the well-known *potato disease*—are due to the attacks of somewhat similar fungi.

Yeasts. The alcoholic fermentation of beer or wine is brought about by the presence of hosts of microscopic fungi, spheroidal or egg-shaped, and mostly propagating by means of budding, though spores may also be formed under some circumstances. Any number of them can be seen in a drop of liquid yeast [2], or "barm," placed under a fairly high power of the microscope.

Bacteria. These excessively minute fungi [1], which are of numerous forms, rod-shaped, spherical, spiral, etc., are dealt with fully in the course on Bacteriology. They propagate by transverse splitting (*fission*) and also by spores, and play a very important part in the economy of nature. Many infectious diseases—consumption, typhoid fever, cholera, leprosy, etc.—are brought about by them, and putrefaction or decay is due to their presence. On the other hand, they are of great importance in the "ripening" of milk and the maturation of cheese, in the formation of acetic acid and the preparation of flax, and so on. Many of them take part in the cycle of chemical changes which is constantly going on in the soil, and they have much to do with the successful raising of crops.

Group 3. Lichens. All are familiar with the grey and yellow incrustations on stone and bark [9, 10], and the branching grey or greenish tufts on many trees, which go under this name. It is only necessary to say here that every *lichen* is a sort of compound or joint-stock organism, consisting of an *alga* and a *fungus* in intimate association. The former does the feeding, while the latter is concerned with the production of spores, which are formed in flat or cup-shaped structures.

THE SCIENCE OF A PLANT

The meaning of the lavish profusion in form and other characters of the higher plants will best be understood if we first briefly review the essential features of a typical example, endeavouring to find the use of every detail of every part, the physiological meaning of every character. Nature is essentially utilitarian.

and even such things as the colours and scents of our favourite flowers are not to be interpreted as merely ministering to human tastes, but as being of the greatest practical importance to their possessors.

The Struggle for Existence. So numerous are the differences between the well-nigh innumerable species of seed-plants—and the remark applies to the other phyla—that any attempt to find a clue to guide us through the maze would be well-nigh hopeless were it not for the fact that they are all constructed on one common plan, it being indeed a case of "unity in variety." This variation in all sorts of ways has been brought about by the keen struggle for existence which everywhere takes place, and may be observed in any tangled hedge-row or rankly-growing meadow, in the deep recesses of the tropical forest, and the dense covering of the heather-clad moorland. It is a struggle for bare foothold, a competition with other plants for food and light, a perpetual endeavour to resist the unfavourable influences of weather and the attacks of animal foes. It is not merely a struggle for the maintenance of the life of the individual, but for a continued existence of the species, for the production of healthy seeds which may in their turn have some chance—albeit a small one—of carrying on the never-ceasing warfare in their turn.

Hence have gradually been evolved [see BIOLOGY] all sorts of shapes and forms, differences in size and habit, diversities in colour and odour, and endless modifications in structural detail, all having to do with the maintenance of the existence of the individual or of the species.

Fundamental Plan of Structure. It will therefore be apparent that our study of seed-plants may best be begun by considering the *fundamental plan of structure* which dominates the almost endless differences in detail. We have already made a start in this direction by enumerating the leading features which enable us to define the phylum. Where—as in an ordinary course of Botany—theoretical and practical work are associated and co-ordinated, it is a usual and desirable practice for certain actual common *types* of plant to be carefully worked out in the laboratory as regards form and structure. Here, however, in order the better to perceive the general plan, and to avoid being led into side-paths by comparatively unimportant matters, it will be well for us to consider a *theoretical type*, or *pattern plant*, mentioning actual species where it seems advisable for illustration.

Life of the Individual. In our pattern plant [19] we shall find an underground part, the *root*, and an overground part, the *shoot*, which consists of a *stem* bearing *leaves*. Both root and stem are more or less branched, each branch of the latter arising in the angle (*axil*) at the base of a leaf. The branching form is very characteristic of higher plants, and the reason for it is not far to seek. In order to live and grow, a plant must feed and breathe. Its food consists of liquid taken from the soil and gas from the air, to absorb which a large external surface is necessary. Breathing, on the other hand, involves the absorption of oxygen gas, while at the same time carbonic acid gas passes out to the exterior, so that here, again, surface area is of importance. It is obvious that an increase in surface, so advantageous for both feeding and breathing, is conveniently brought about by branching of the stem and root.

The Root. As the work of the root has to be done in the ground, it is not surprising to find that it reacts positively to the action of gravity and negatively to that of light—*i.e.* its direction of growth corresponds with the downward pull of gravity, and it may be said to shun the light. The main root goes vertically downward, while the side-roots are more or less oblique. Moisture also exerts a strong attraction. During the life of the plant a root continually elongates owing to active growth at its tip, which is provided with a *growing point* full of *protoplasm*, and covered by a thimble-shaped sheath known as the *root-cap*, which prevents the surrounding particles of earth from injuring it.

The root anchors the plant in the ground, supporting the stem and leaves. The branching form is clearly adapted to this use, while the size and extent of the root-system are proportionate to the weight of the parts above ground which require to be held up. As a plant increases in size its roots not only become longer and more numerous, but also—in many cases—gradually thicken. It also appears that from time to time they contract longitudinally, being thus drawn taut—which contributes in no small degree to their effectiveness as means of fixation.

Each root is traversed by a *central core*, largely composed of longitudinal woody fibres of great toughness, and thus able to withstand the very considerable pull that is brought to bear upon them in windy weather. Examination of any large forest tree that has been torn up by a storm will at once show the size and complexity of the root-system.

The Food of the Plant. Ordinary earth consists of particles of various size to which films of water cling, and this water constitutes a large part of the food of the plant. It contains small quantities of various mineral matters in very dilute solution, so much so that a comparison may be made with ordinary drinking water.

The nature of the food which is taken up from the soil can be readily determined by growing plants in artificially-prepared solutions [20]. Water itself is of the first importance, for not only is it abundantly present as such in the living plant, but it supplies two of the chemical elements—hydrogen and oxygen—which enter into the composition of protoplasm, and are also essential components of many substances which are the products of vital activity, *e.g.*—wood and starch. But a plant will not grow and thrive if its roots are supplied with nothing but pure water. There must also be small quantities of simple mineral compounds containing seven other elements, *i.e. Nitrogen, Sulphur, Phosphorus, Potassium, Calcium, Magnesium*, and *Iron*. At least the first three of these help to build up protoplasm, while the others are of importance in various ways.

Some plants require still other kinds of food for their complete well being. A well-known example is afforded by the grasses—including our cereal crops—which contain a considerable amount of flinty matter or *silica* (SiO_2) in their stems and leaves, taking this up from certain siliceous compounds in the soil. Apart from cases like this, plants differ considerably among themselves as to the exact composition of the food they require, which is one reason why it is desirable for farmers to adopt a *rotation of crops*, instead of growing one kind of plant continuously in the same field. Since a given soil may from the first be deficient in one or other of the essential kinds of plant-food, or may have become "exhausted" of its supplies, the necessity for manuring also becomes apparent. In such matters expert advice is clearly a desideratum. [See AGRICULTURE.]

The Root as Food Finder. The work of taking food up from the soil is done by the younger parts of roots, especially their ends, and a few details on the structure of roots here becomes necessary. All but the lowest plants are made up of large numbers of variously-shaped fragments of protoplasm known as *cells*. These are usually of microscopic size.

A typical cell [21] is covered by a delicate elastic membrane, the *cell-wall*, composed of a substance (*cellulose*), with which everyone is familiar in the form of cotton wool. Within the wall is a layer of protoplasm surrounding a relatively large space full of fluid, the *cell-sap*, and often traversed by protoplasmic strands. A small part of the protoplasm is specialized into a rounded *nucleus*, which plays a very important part in controlling the life of the cell. It must also be noted that the living healthy cell is turgid, *i.e.* in a state of distension, so that the elastic cell-wall is on the stretch. An aggregation of similar cells is a *tissue*.

The outer part of a young root (*cortex*) is composed of layers of cells, resembling in essential particulars the typical one just described. Those making up the outer layer are drawn out into slender tubes externally, and constitute what are known as the *root-hairs* [22]. It is these which take up the food-solution from the surrounding soil, by means of *osmosis*, a name which is applied to the well-known physical process of diffusion of liquids through *membranes*. Or, in other words, if two different liquids are separated by a thin moist membrane, each of them will soak or diffuse through the membrane. In this case the two fluids are the food-solution outside the cell and the cell-sap within it, while the moist membrane is represented by the cell-wall. As the incoming fluid here largely exceeds in amount that which goes out, the plant is a continual gainer. The fluid thus gained, or part of it, now diffuses into the next layer of cells, and so on, until the central core of the root is reached.

How the Root Feeds Itself. The cell-sap, which diffuses out of the root by means of osmosis, is slightly acid, and helps to dissolve the particles of the soil, *i.e.* assists in the preparation of more food. This is facilitated by the fact that the root-hairs come into very close contact with the particles in question. This "*self-help*" on the part of roots is very prettily illustrated by placing a polished slab of limestone in the bottom of a flower-pot in which a plant is growing. After a time the roots will spread over and corrode the limestone, etching their outline upon it.

It will be convenient to speak of the watery mineral solution of food taken in from the exterior as the *crude sap*. This is conducted upwards by the central *vascular core* to which allusion has already been made. The actual structure of this is very complicated, and it is enough to say here that part of it consists of elongated woody strands, formed by the alteration and elongation of cells. They have altogether lost their protoplasm. Some of them are continuous tubes or *vessels*, made up from longitudinal rows of cells from which the transverse party-walls have disappeared. The exact way in which conduction of crude sap takes place is imperfectly understood. It is partly due to capillary attraction, and *osmosis* pushes from behind, so to speak. As the vascular bundles of the root-core are continuous with those of the stem, and these, again, with those of the leaves, we have a definite path provided for the upward current of crude sap.

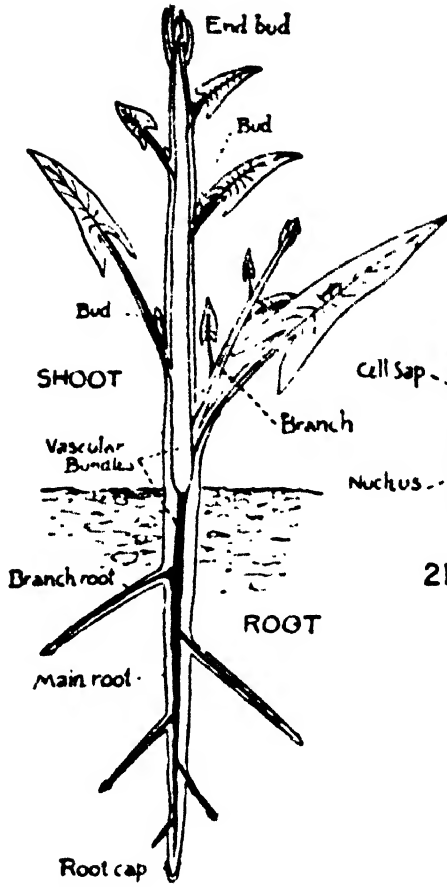
Like all living parts of the plant, the root breathes, but as the leaves are of greatest importance for this kind of work, it will be well to postpone consideration of the nature and meaning of this process.

The Stem. The stem of the plant is charged with the office of displaying the leaves to the best advantage, and of serving as the means of communication between them and the root. As we might naturally expect, it reacts negatively to gravity and positively to light, growing away from the earth, and avoiding darkness. The main stem typically assumes an erect position, while the branches are directed obliquely upwards. The positive action of light is well seen by cultivating a box of mustard and cress in a window, when the seedlings will be found to bend away from the relatively dark interior of the room.

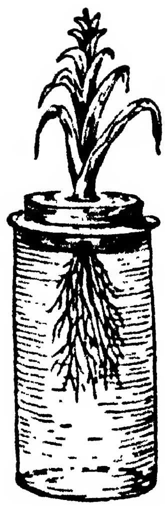
The main stem and its branches continually elongate [23], in much the same manner with the root, except that the delicate growing parts at their tips are not protected by caps, but by the undeveloped leaves, which are folded over them. When the life of a plant is indefinitely prolonged it frequently happens that the stem regularly increases in thickness, thus enabling it to bear the increasing weight of the over-ground parts. This is best realized by examining the cut end of a tree-stump, when the wood will be found to be arranged in concentric annual rings, of which one is formed each summer, external to those which already exist. The number of such rings may amount to several hundreds, or even run into four figures.

Structure of the Stem. Examination of a cross-section of the stem of our pattern plant [24] will show that it is covered by a layer of flattened cells, the *epidermis*, of which the outer cell-

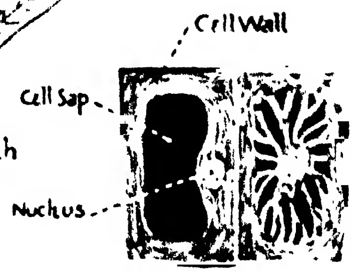
TYPES OF PLANT LIFE



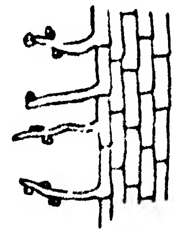
19. PATTERN PLANT.



20. WATER CULTURE.

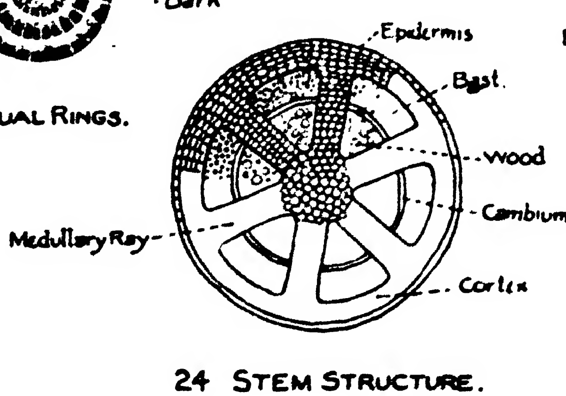


21. TYPICAL CELLS.

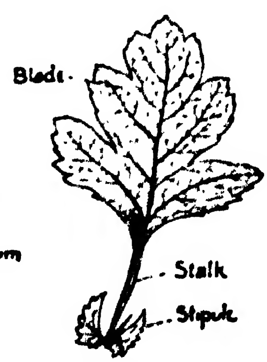


22. ROOT HAIRS

23. ANNUAL RINGS.



24 STEM STRUCTURE.



25. LEAF.

SKETCHES ILLUSTRATING BOTANICAL STRUCTURE AND PLANT LIFE

walls are thickened as a means of protection. Some distance within this we shall see a ring of *vascular bundles*, each of which consists internally of *wood*, and externally of *bast*, while between the two there is a narrow zone known as the *cambium*. The *wood* is made up of elements resembling the woody fibres and vessels of the root, while the *bast* is essentially composed of elongated *bast-vessels*, formed by the modification of cells. Their walls are not of woody nature. Their most important use is to conduct downwards the prepared food or *elaborated sap* which is prepared by the leaves, and they are continuous wi h similar elemen's found in the vascular core of the root and the vascular bundles or veins of the leaves The *cambium* is a thin layer of elongated actively dividing cells, with thin walls and abundant protoplasm

The Stem as a Means of Support. The rest of the stem is composed of more or less typical cells, of which those in the cen're make up the *pith*, those external to the bundles the *cortex*, and those between the bundles *the medullary rays*, by which cortex and pith communicate The structure of a thickened stem, is, of course, much more complicated

The stem is divided into *nodes* -from which leaves and branches arise and intervening parts, the *internodes* In order to hold up the leaves, especially during windy weather, it is clearly of advantage that the chief mechanical tissue, *i e* the vascular bundles, should be arranged in an advantageous manner Hence the ring like disposition seen in the cross section, which gives much greater resisting power than would be attained by a massing together in the centre Greatly increased firmness is brought about by transverse and oblique bands, which unite the bundles girder fashion at the nodes Nature thus establishes her humblest creations upon foundations more perfect than any which man can devise

The possession of a considerable amount of elasticity is another important point deserving attention Some plants, such as grasses, have internodes which attain the maximum of strength with the minimum expenditure of material For each of them contains a large central space, and the well known mechanical principle of the hollow column is thus exemplified. A piece of bamboo shows this to perfection. In young and juicy stems the pith and cortex contribute even more to effective support than do the vascular bundles. For the distension of the walls of their cells by sap results in firmness combined with elasticity When such plants wither their limp condition is brought about by the loss of water

The Leaf. Leaves are flattened outgrowths from the *nodes* of the stem, with which their tissues are completely continuous. They are of various kinds, but the ones with which we have here to do are the *foliage leaves*, to which alone the term *leaf* is applied in ordinary language

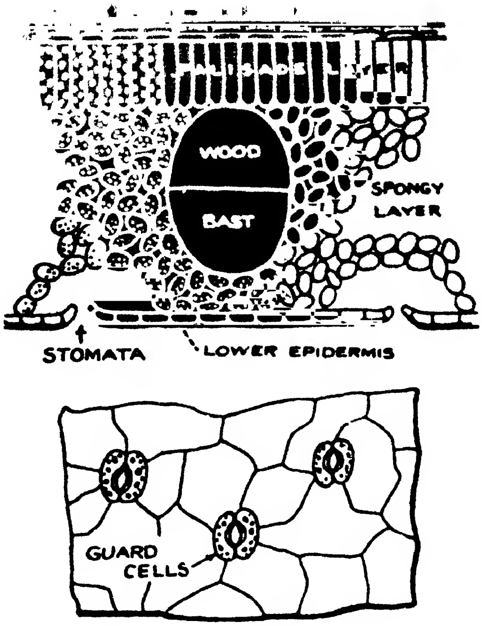
A fully-developed leaf [26] consists of a flattened *blade*, borne upon a *stalk*, at the base of which there is very often a pair of flattened outgrowths known as *stipules*. These last, however, are often absent, and many leaves are also destitute of stalk. In some cases, *e.g.* grasses, the attached part of the leaf is in the form of a *sheath* which wraps round the stem. Leaves present almost endless variations in shape, proportion, and mode of arrangement on the stem.

The leaf-stalk closely resembles the stem in structure. Turning to the more important leaf-blade [26], we find externally a protective layer of *epidermis*, which is very tough and firm in some cases, as in the leaves of holly and laurel As the blade is horizontally expanded, we can distinguish between upper and lower epidermis It is characteristic of the latter that it should be perfora'ed by a large number of minute holes, by means of which the interior of the leaf is placed in communication with the exterior Each such pore is known as a *stoma*, and it is bounded by two guard-cells, which are capable of altering their shape so as to vary the size of the slit between them Stomata are also found in the epidermis of young stems, nor are they necessarily confined to the undersides of leaves In the floating leaf of a water lily, for example, they are only found in the upper epidermis, which is next the air

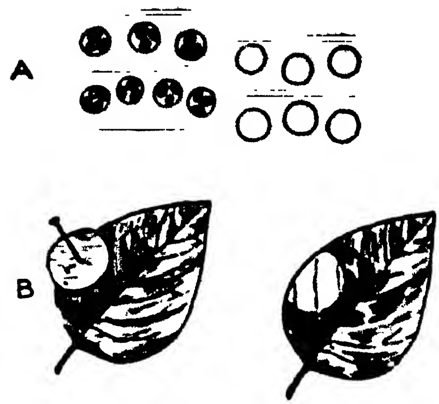
The Lungs of the Plant. Between the two layers of epidermis there is a mass of green *cellular tissue*, divisible into an upper layer of cells elonga'ed at right angles to the surface thus giving an appearance which has earned for it the name of *palisade layer*—and a lower *spongy layer*, which exhibits no such regularity Between the cells of the spongy layer are air spaces, which form part of a continuous system of narrow chinks and passages by which the plant is traversed If the blade of a thick stalked leaf is immersed in water, the existence of this continuous set of air passages may be demonstrated by placing the cut end of the stalk in the mouth and blowing into it as hard as possible Minute bubbles of air will then be seen to come off from definite points on the leaf-blade, having made, in fact, their exit through stomata The cells of both palisade and spongy layers contain numerous specialised rounded particles of protoplasm coloured green by chlorophyll These are the *chlorophyll granules* [27A]

The veins of the leaf blade are its *vascular bundles*, consisting of wood above and bast below These bundles are so arranged as to prevent the leaf from tearing easily, while at the same time they guard against the collapse of the delicate green cellular tissue, by keeping the two layers of epidermis well apart

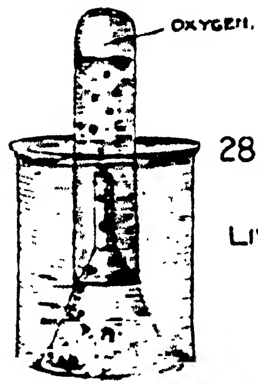
We have seen that the food solution taken in by the root contains nine chemical elements which are essential to the life of the plant, but there is still one other which is indispensable—*carbon*, which is one of the components of protoplasm, as well as of cellulose, wood, and many other characteristically vegetable substances The source from which this element is obtained is carbonic acid gas or *carbon dioxide* [CO_2], which makes up a small percentage of the atmosphere. One of the uses of the stomata is to permit this gas to pass readily into the interior of the leaf.



26. LEAF STRUCTURE.

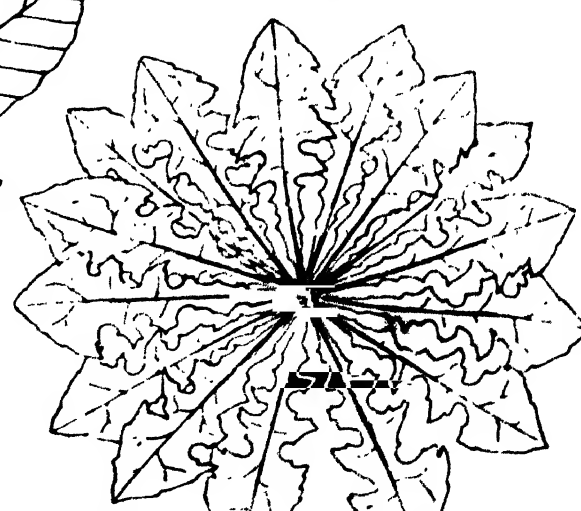


27 STARCH FORMATION



28 OXYGEN GIVEN OFF BY LIVING PLANTS

29 LEAF MOSAIC OF BEECH.



30. ROSETTE OF DANDELION

SKETCHES ILLUSTRATING BOTANICAL STRUCTURE AND PLANT LIFE

How the Plant Uses Sun-power. The food of the plant consists of the simple substances already mentioned, *i.e.* *carbon dioxide*, *water*, and small quantities of mineral matter. These have to be built up step by step into organic compounds till, in the end, living substance, or *protoplasm*, is produced. The early steps in this process—which bridge over the gap between non-living and living matter—can only be effected—by protoplasm itself—in daylight with the co-operation of *chlorophyll*. This is the most important duty of the green part of the leaf, which is aided in the work by the green outer part of the stem.

A chemical reaction takes place between the water [H_2O] which the leaf receives from the root and the *carbon dioxide* [CO_2] it takes in from the air, resulting in the formation of an organic substance composed of carbon, hydrogen, and oxygen, a formation which could not be effected were it not that *chlorophyll* enables the energy of sunlight to be utilised for the purpose. In other words, though the protoplasm of the leaf does the up-building work, it has to use *sun-power* for the purpose, and *chlorophyll*—how, is not clearly understood—alone renders this possible. If kept in the dark, a green plant soon becomes pale and sickly, for its constructive work is arrested.

Starch. The further steps in the formation of plant-substance are too complicated to be followed here, and it is enough to say that the first visible product is *starch*, another compound made up of carbon, hydrogen, and oxygen. That grains of this substance are actually formed in the leaf can be proved by microscopical examination, and also by a simple chemical test. It is a well-known fact that starch turns blue when subjected to the action of a solution of iodine [in *potassium iodide*—(KI)], which can be obtained from any chemist. If we take a leaf that has been exposed to the sun for some time, and place it in this solution, it will rapidly become of a dark blue colour, thus proving the presence of starch. By pinning two round pieces of cork to part of a leaf [27A], one above and one below, we can keep off the sunlight and thus locally prevent the formation of starch. If a leaf of which part has thus been shaded is placed in the iodine solution, the part in question will not turn blue, thus showing that no starch is present. It may be added that the palisade layer of the leaf is of most importance in the constructive work just described.

Oxygen from the Leaf. When any organic substance is formed in the green parts of a plant by chemical reaction between water and *carbon dioxide*, a large part of the oxygen contained in these substances is not required for the purpose. This, as a sort of bye-product, passes into the surrounding air, which we know is a mixture of gases, about 21 per cent. being oxygen, an element which is constantly being used up in the breathing of animals, and also in combustion.

A convenient way [28] of demonstrating that oxygen is given off during the feeding processes of green plants is to put some water-plants in a glass vessel, covering them with a funnel, and placing an inverted test-tube full of water over the stem of this. If the whole arrangement is now exposed to light small bubbles of gas will soon be seen to rise from the plants, gradually filling the test-tube. By applying the usual tests it is easy to prove that this gas is actually oxygen. If, for example, a glowing splint of wood is plunged into the tube it will be at once re-kindled.

The Organic World at a Standstill. Were it possible to destroy all existing *chlorophyll*, and to prevent the formation of more, the organic world would soon be brought to a standstill, and life would become extinct. For no more plant-substance could be built up from non-living material, and the vegetable world would therefore soon cease to be, while, as animals directly or indirectly depend on plants for food, they, too, would quickly die out.

Quite apart from this, the breathing of plants and animals, and the processes of combustion, continually exhaust the oxygen of the air and increase the proportion of poisonous *carbon dioxide*. The composition of the atmosphere is, in fact, only kept normal by the utilization of carbon dioxide as food by green plants, with concomitant liberation of oxygen. As we have seen, this process is absolutely dependent upon chlorophyll.

Starch—converted into soluble sugar—and certain other organic substances, are constantly being drained off from the leaves, as *elaborated sap*, to all parts of the plant, serving for the repair of waste and the furtherance of growth. They partly diffuse from one living cell to another, and partly travel along the bast-vessels of the vascular bundles.

Transpiration of the Leaf. The leaf, and the stem to a less degree, are constantly giving off water vapour—*i.e.*, *transpiring*. This vapour is continually evaporating from the delicate green cells of the leaf into the adjoining air-spaces, from which it makes its exit by means of the stomata. That transpiration actually takes place is shown by the way cut leaves wither, and may easily be demonstrated by placing several such leaves with their stalks in a glass of water, which is then covered by a glass plate. If the whole is now put in a sunny window moisture will gradually accumulate on the under side of the glass plate.

An easy and pretty experiment to prove that transpiration takes place from the *under* side of the leaf, where the *stomata* are situated, can be made by taking advantage of the fact that cobalt paper [prepared by drying blotting-paper that has been soaked in a 5 per cent. solution of cobalt chloride], which is blue when dry, turns pink on being moistened. A piece of this paper is placed on a glass plate, and covered with a perfectly dry leaf under side downward. A second piece of cobalt paper is then put on the upper side of the leaf, and a second glass plate over all. After exposure for a short time to sunlight it will be found that the paper which has been in contact with the *under* side of the

leaf has become pink, while the other piece retains its blue colour.

Use of Transpiration. The promotion of the upward current of crude sap is of the utmost importance, for the amount of mineral matter dissolved in it is so small that a constant stream is necessary to furnish the leaves with the requisite amount for their constructive work. Some of the causes of the upward flow of sap have been mentioned in dealing with the root, and transpiration would appear to be a supplementary agency, for the loss of moisture by the leaves must promote the ascending current.

Organisms are constantly and necessarily undergoing disintegration, thereby setting free the necessary energy for the conduct of the various vital processes. This down-breaking process is essentially one of *oxidation*, a kind of combustion, comparable in a broad sense to what takes place in a fire. Hence the necessity for a supply of oxygen, derived from the air. Breathing or Respiration is in fact the taking in of oxygen, together with the elimination of carbon dioxide, which is one of the useless products resulting from the process of disintegration.

Breathing of Plants and Animals. It is very generally but erroneously imagined that, while animals take in oxygen and give out *carbon dioxide* in the process of breathing, the reverse is true for plants. As a matter of fact, both breathe in precisely the same way. But, as we have seen, a green plant is constantly giving off large quantities of oxygen during the day, as a bye-product of its feeding processes. And this has been mistaken for a product of respiration. In reality, some *carbon dioxide* is also given out as the plant breathes.

During the night, when the evolution of oxygen ceases, owing to the absence of light, it is easy to prove that a plant breathes exactly like an animal. Place a vigorously growing pot-plant at night in a cylindrical glass vessel just large enough to hold it, and close the mouth of the vessel by a greased glass plate. To prevent access of light it is best to put the jar with its contents in a dark cupboard. If, next morning, a lighted taper is plunged into the jar it will be extinguished, showing that the oxygen of the air has been used up and that carbon dioxide has presumably been given out. The latter point may be definitely established if a watch-glass full of lime-water has previously been placed at the bottom of the jar, for the liquid will be found to have become milky during the night. This is a well-known test for carbon dioxide.

The Fight for Light. Leaves may be attached one or more at a *node*, those of two successive *nodes* not being situated vertically one above the other. They may be stalkless, or else possess stalks of varying length, and there are all sorts of possibilities as to the size and shape of the blade, which may not be uniform even in the same plant.

There are several reasons for this large amount of diversity, one being the necessity for advantageous display as regards light. The horizontal position of the leaf-blade in ordinary cases has obvious reference to the necessity for getting as much of this as possible, while the mutual arrangement of the leaves of the same plant is of such a nature that they screen one another from the light as little as possible. Hence the origin of *leaf mosaics*, which are well seen in the case of ivy growing on a wall, or the branches of many forest trees, such as beech or elm [29]. Examination of one of these plants will show that the leaves fit into the spaces between one another, so as to form a more or less continuous sheet of green. In tangled undergrowth the leaves often have to accommodate themselves to those of their jostling neighbours, which partly accounts for the much divided form they often assume.

The Unending Warfare of Nature. Many dominant plants secure part of the soil for their sole benefit by keeping away the light from other forms, which is tantamount to starving them out. But little can grow, far less flourish, under the dense foliage of many forest trees, while some herbs adopt aggressive tactics of another kind. The daisy, dandelion, plantain, and many other rampant weeds, possess a dense rosette of leaves resting on the ground, seizing, as it were, a small circular holding for their own exclusive use [30]. The arrangement is due to suppression of the internodes, whereby the leaves belonging to a considerable number of nodes are of necessity crowded together.

The dandelion, when growing in a meadow, is often in danger of being itself deprived of light by the luxuriant growth of the surrounding grasses. Under such circumstances the leaves of the rosette abandon their horizontal position and direct themselves more or less upwards. To make the most of the scanty light attainable it has to convert itself into what is termed a *shade-plant*, though it is more usually found growing as a *sun plant*, in the open waste places which are its favourite habitat. Not only do its leaves turn upwards towards the light, but they become larger and more delicate, while the characteristic deep indentations in their edges more or less disappear.

[DESCRIPTION OF THE FRONTISPIECE. The plate forming the frontispiece of this part of the SELF-EDUCATOR is dealt with in the earlier part of this article. The contents of the plate are: 1. Bacteria; several species. 2. Yeast: *Saccharomyces cerevisiæ*, after Vines. 3. Green Mould: *Penicillium glaucum* (Vines). 4. Diatoms: several species. 5. Desmids: several species. 6. Seaweed: *Melobesia polymorpha; Chorda lomentaria; Delesseria ruscifolia; Hiliseris polypodioides; Asperococcus Turneri; Fucus vesiculosus*. 7. Toadstools: *Coprinus atramentarius; Russula emetica; Agaricus muscarius*. 8. Fungus on Beech Stem: *Fistulina hepatica*. 9. Lichen on Fir Stem: *Parmelia parietaria*. 10. Tufted Lichen on Fir Branch: *Usnea barbata*. 11. Liverwort: *Marchantia*. 12. Mosses: *Polytrichum commune*. 13. Ferns: *Polypodium vulgare*. 14. Horsetail: *Equisetum arvense*. 15 and 16. Fir Stem and Fruiting Branch: *Pinus sylvestris*. 17. Beech Stem: *Fagus sylvatica*. 18. Broom and Fruit: *Cytisus scoparius*.]

To be continued

A SHORT DICTIONARY OF TERMS IN NATURAL HISTORY

See also A Short Dictionary of Biology on page 88

ALBUMINOIDS—Complex substances chiefly of carbon, hydrogen, oxygen, sulphur, and, sometimes, phosphorus.
Ambulacrum—A groove in the star-fishes which lodges the tube-feet.
Ampulla—The swollen part of a semi-circular canal in the internal ear of vertebrates. Or a small sac connected with the tube-foot.
Atavism—The appearance of a trait unlike the immediate parents, but resembling a more remote ancestor.

BARB—One of the branches of a feather.
Biconcave—Hollow on both sides like the vertebra of a fish.
Bivalve—The shell of a mollusc when composed of two parts.
Brood-parasitism—A habit of some animals, such as the cuckoo, of placing their young with other parents.

CALYX—The outermost leaves of a flower.
Cephalopods—The cuttle-fishes, and their allies.
Cetacea—The order of mammals which includes the whales.
Cheiroptera—The order of mammals which includes the bats.
Chelonia—An order of reptiles which includes the tortoises.
Chordata—All animals which possess a notochord.
Chrysalis—The motionless pupa of butterflies and moths.
Chyle—The fluid which results from the action of digestion upon food.
Coccyx—The end of the spinal column.
Cœlom—The body cavity.
Colloid—Substances which do not readily pass through membrane pores.
Ctenoid—Term applied to certain fish scales with the hinder margins fringed.
Cycloid—A term applied to those scales of fishes which have a circular, or elliptical, outline with an even margin.

DECIDUOUS—Structures which are shed during the life of an organism.
Diphyodont—Applied to mammals which have two sets of teeth.

ELYTRA—A beetle's anterior wings.
Entomophilous—Flowers which are fertilised by insects.
Eozoic—The earliest geological period.

FLORA—The plants of any region.
Furculum—The "merrythought" bone of birds formed by the union of the two clavicles.

GANOID—Those scales in fish which have an inferior bony layer.
Gastrula—A term applied to that stage of the embryo which exhibits a double layer with mouth and digestive cavity.
Germinal disc—That part of the egg which develops into the embryo.
Gill-cover—The flap which overlaps the gill slits in fishes.
Gonophore—A bud in which the egg cells, or sperms, are produced.

HETEROCERCAL—The unequally-lobed tail in fishes.
Hock—The ankle in a horse's hind limb.
Homocercal—Equally-lobed fish tails.

INFUSORIANS—A class of the protozoa.
Insectivora—An order of mammals.

KAINOZOIC—The most recent geological epoch.

LACERTILIA—The order of reptiles including the lizards.
Lepidoptera—Order of insects which includes butterflies and moths.

MAMMALIA—The class of vertebrates which suckle their young.
Mantle-cavity—The space in molluscs which contains the gill, and into which the excretory organs generally open.
Marsupials—An order of mammals.
Medusa—The egg-producing stage of a jelly-fish, usually free swimming.
Mesozoic—The geological epoch which preceded the kainozoic.
Mongrel—A cross between two varieties of the same species.
Monœcious—Those individuals in which the two sexes are united.
Monophyodont—Mammals which develop only one set of teeth.
Monotremes—The lowest order of mammals.
Morula—An embryonic stage in which the segmented ovum is not hollow, but solid.
Mule—A cross between a horse and an ass.
Muscle—A definitely shaped piece of flesh.
Mutualism—The association of two organisms for the benefit of both.

NAGANA—Fly sickness; a fatal disease of horses caused by a parasite which is carried by the tsetse-fly.
Nearctic Region—The northern part of the New World.
Neuter—Having no fully developed sex.
Normal—Conforming to the ordinary standard.
Nucleated—Possessing a nucleus.
Nucleolus—A minute body inside a nucleus.
Nymph—The active pupa of certain insects, the stage which hatches from the egg.

ODONTOPHORE—The masticating organ in molluscs and cuttle-fishes.
Operculum—The gill cover in many fishes, also the horny plate which closes the shell of some molluscs.
Opisthocœlous—Concave behind, as in some vertebræ.
Oriental region—Southern Asia, together with part of the East Indies, the Philippine Islands, and Formosa.
Otocyst—A vesicle filled with fluid containing some solid particles. A simple form of hearing apparatus, probably also a balancing organ.
Otolith—A hard substance inside the hearing organ.
Ovipositor—An organ at the hinder end of the body of a female insect by means of which holes are made in plants for reception of the eggs.
Ovule—The portion of a plant which becomes a seed after fertilisation.

PALÆONTOLOGY—The science which deals with fossils.
Perissodactyla—Hoofed quadrupeds which have an odd number (one or three) of toes.
Pineal body—A structure in the roof of the vertebrate brain which probably represents the remains of a dorsal eye in some reptiles.
Pinnate (or **Pennatiform**)—Feather-shaped.
Pisces—The class of fishes.
Pisiform—A small round wrist bone.
Placenta—The organ in the higher mammals which establishes the vascular connection between the mother and the fœtus; the after-birth.
Placoid—Irregular, thick, bony scales, such as found in sharks and rays.
Pleura—Serous membrane covering lungs of air-breathing vertebrates.
Pollex—The innermost digit of the fore-limb—in man the thumb.
Procœlous—Concave in front, as in some vertebræ.
Proglottis—A segment, or joint, of a tape-worm.
Pronation—The act of turning the palm of the hand downwards.
Pyriform—Pear-shaped.

RAPTORES—The birds of prey.
Recapitulation—The repetition of the successive ancestral stages in the development of an organism.
Rennin—A ferment in the gastric juice which curdles milk.
Resemblance—General: a harmony with surroundings, causing the organism to be inconspicuous. It may be protective or aggressive, or both. Special: a likeness to some particular object in the environment.
Reticulum—A network; the second division of the complex stomach of a ruminant.
Retractile—An organ which is capable of being drawn back.
Rodentia—An order of mammals, gnawers.
Rostrum—The suctorial organ formed by the appendages of the mouth in certain insects; any kind of beak.
Rotifera—The wheel animalcules.
Rudimentary organ—A structure which is not fully developed.
Rumen—The first division, or paunch, of the complex stomach of a ruminant.
Rumination—Process of cud chewing.

SACRUM—The part of the backbone with which the pelvic arches unite.
Scolex—Embryonic stage of tape-worm.
Sessile—Not supported by any stalk.
Setæ—Bristles.
Spermaceti—Liquid fat obtained from the sperm whale, contained in a deep depression in the side of the skull.
Spinnerets—Small projections on the under side of the abdomen of spiders, on which silk glands open.
Spiracle—The apertures of the breathing tubes in insects; also the single nostril, or blow-hole, of cetaceans.
Supination—The act of turning the palm of the hand upwards.
Suture—The line of union between two immovable parts, as in skull bones.
Swim-bladder—An outgrowth from the alimentary tube of some fishes.
Swimmerets—The limbs of crustaceans which are adapted for swimming.
Symmetry—Regularity of structure, which may be either radial or bilateral (having right and left sides).
Symphysis—The union of two bones in which there is very limited motion.

TÆNIA—An order of tapeworm.
Teleostei—The order of the bony fishes.
Tetradactyl—Having four digits.
Tortoise-shell—A product of the horny plates obtained from certain turtles.
Trichocyst—Minute rods found in some Infusorians which are projected from the outer layer of the body for defence.
Tunicata—The sea squirts.

UNIVALVE—The shell of a mollusc composed of only one piece, as in the snail.
Urostyle—The hindmost portion of the backbone of a frog.

WAMPUM—The shell money of the North American Indians.
Water-vascular system—An arrangement of tubes, as in star-fish, concerned with locomotion and respiration.

ZOOTOMY—The science of the anatomy of the lower animals.
Zymotic—A term applied to diseases which are contagious.

BUYING, STOCKING, AND SELLING

Three great essentials. Errors and Extravagance in Buying. Stock to Avoid. Terms of Payment. Important points to bear in mind.

By W. B. ROBERTSON

THERE are many points which are peculiar to certain trades, and these will be duly discussed in considering the departments to which they apply, but the broad principles which enter into successful business management are general, and capable of application to any branch of shopkeeping.

In every retail business, no matter how small, there are three departments. In large stores these departments may be divided; in small or medium concerns they are united. These departments are *buying*, *stocking*, and *selling*. Each of these, even in a small concern, may be reduced to a system. The more the shopkeeper introduces system to facilitate work, to prevent waste of time, space, and money, the greater will be the accruing profit. The statement may be a self-evident truth, but the small heed given to its teaching by so many shopkeepers in their daily practice is sufficient apology for its enunciation here. Let us go deeper into the subject, and apply our principles of system to the three business departments we have mentioned.

Buying. The most prominent quality in the man who buys should be caution. It is much easier to buy than it is to sell. The successful buyer is he who has the talent of selecting for his stock not primarily the articles he himself thinks best, but those which his customers and the general public will buy most freely. The ability to divest himself of personal predilection or—what is, in its result, much the same thing—the ability to make his own taste coincide with the tastes of his purchasers, is a gift difficult to acquire. It is largely intuitive, and is allied to a distinct type of mind. Experience gives the ability only in a measure. We have known business men, successful as salesmen, whose judgment in buying was so little to be trusted that their only safe course was to refrain rigidly from any interference in the buying department. Sometimes the ability to choose saleable merchandise may exist, but the person may still be a comparative failure as a buyer. He may have the inability to resist the temptation to buy far beyond his immediate needs and beyond the absorbing possibilities of his district. How often the commercial traveller makes the confession, "I have got something here I want to sell to Messrs. A and B. I know that A won't buy it, but I shall touch B about it, and am sure of placing a few gross with him."

The traveller who is wise in his generation to this extent exhibits one of the most successful qualities of a salesman—the power of gauging the individual leanings of his customers and working upon that power to his own purposes. But our immediate concern in this place is for the purchaser, whom we would warn of the pitfalls in his path.

Extravagance in Buying. With many men the passion for the appearance of doing an enormous trade is strong, and some have ruined themselves by a course of conduct into which the weakness has led them. We have in mind a case in point. In the Bankruptcy Court recently a retail chemist appeared for examination. He was a competent pharmacist, punctilious in attention to his business, which was large, and should have been profitable. When his stock came to be realised for the benefit of his creditors it was found that his cellars contained unopened packages of goods to the value of a year's turnover. These packages had accumulated during a period of years, and had been collected solely through the man's desire to acquire in the eyes of the wholesale trade a false importance as a buyer. In this particular case, however, the man was totally incapable of business, and his case is an extreme rather than a typical one. Not often, perhaps, is the consequence of the temptations of buying so dire in its results.

In trades which change with the seasons the need of a buyer who can gauge the buying power of his customers is supremely essential. The group of clothing trades is the most prominent in this class. We find that nearly every draper has his annual, semi-annual, or quarterly clearing sales. In some measure these are genuine sales of end-of-season goods and remnants, such as are unavoidable in any business. But much of the turnover of the sale consists of articles bought for the purpose of the sale itself. Those who buy these things in the belief that they are genuinely reduced goods labour under a delusion which the salesman finds it no part of his business to remove. Some people may hold that the moral problem enters into such proceedings, and upon this question we make no pronouncement. But the point we wish to make is that the smaller the quantity of ordinary merchandise thrown upon the sale counter and cleared off at less than cost price or at less than proper selling price, the higher is the ability of the buyer in estimating the purchasing power of his market.

Errors in Purchasing. Sometimes th errors made in purchasing are almost beyon belief, and indicate a negligence that is culpab and deserving of overloaded shelves of ba or unsaleable stock. We may point a moral an perhaps even adorn a tale by citing an instan of what we mean. There are in England ar Scotland, at the time of writing, many iro mongers to whom it is dangerous to menti the name of a certain inexpensive knife-clean The manufacturers of the particular article

which we refer succeeded in persuading retailers to purchase grosses of their speciality when dozens would have satisfied all needs. Simple calculation would have shown the merchant that he was buying enough knife-cleaners to provide one for every man, woman, and child in his town, and reflection would have proved the folly of buying in such quantities. These men have been sufferers from the persuasive eloquence of smart salesmen and from their own inability to take into consideration the factors which should govern any projected purchase.

Stock to avoid Buying. A successful buyer is he who conducts his business upon the smallest stock in relation to annual turnover. Many traders have a dread of being asked for anything which they do not have. Such men have a mistaken sense of responsibility towards the public. Their notions of business lead them to cumber their warehouses with goods which are asked for only, perhaps, once in a number of years, and the profit gained from the sale of such articles is in no way commensurate to the expense of buying and stocking them. It must be remembered that every ten-pound note spent in stocking the shelves with slow-selling articles curtails the possibilities of outlay in directions which might be more profitable.

Every buyer, in whatever trade, ought to be thoroughly familiar with the features, qualities, uses and prices of every article for which there is a possibility of request. He should have a collection, as nearly complete as possible, of trade lists arranged for immediate reference, and should be able to tell from the marks upon these lists the discounts or net prices, and show the enquirer the detailed particulars regarding any out-of-stock article. In most cases a properly organised system such as this will effect a sale. One advantage pertaining to the ordering of articles of infrequent request, only after the customer has placed a definite order for them, is that they may be delivered fresh and untarnished from the makers, whereas, if they had been stocked for months or years, they might have become soiled, or be otherwise deteriorated. The expense of special carriage upon goods in occasional demand is usually less than the interest on capital sunk in stocking them, plus the value of the room they occupy, and the frequent loss through deterioration or breakage.

Friendship in Business. An oft-quoted maxim states that there is no friendship in business. This is a hard saying, and it is not quite true. There is, there must be, and there always will be friendship in business. The relations of buyers and sellers, their obligations towards each other, and their frequent intercourse begin in mere acquaintanceship, but, if founded upon mutual respect and esteem, often ripen into friendship. But there is a half-truth in the statement that there is no friendship in business. No man should let his business suffer by reason of friendship. His liking for a firm or for its travelling representative ought not to cause him to continue his patronage of it if his business interests would be better served by changing his market. Other things being equal, business preference should, no doubt, follow personal preference, but to purchase from a friend at a price ten per cent. higher than that demanded by another house is equivalent to a gift of ten per cent. of the price of the package, unless there are compensating advantages in credit terms, delivery conditions, or quality of goods.

Terms of Payment. There is another department in merchant buying, or, indeed, in private or personal purchases, to which there is urgent need of attention. We refer to the terms of credit and payment. Some shopkeepers pride themselves upon having no outstanding obligations. They pay for the goods they receive whenever they have been placed in store. Unfortunately, such men, as every manufacturer and wholesale merchant know, are relatively few compared with the total number of shopkeepers. Error too frequently lies at the other extreme in the manner of payment. We shall consider the laggards later. To the "spot cash" men, the men who believe in immediate payment, we may put the query: "Are you sure that you always get value for your promptness?" When the terms are *three months' credit*, the man who pays cash for his purchases without a special cash discount is not acting fairly to himself. He is unduly generous. Money is worth something. Even the use of money is worth something, and it should be the business of the alert shopkeeper to get that value in return for money paid before the latest date allowable under the contract of sale. Very often the inducements offered by manufacturers in the way of cash discounts are inconsiderable. Especially is this so when the purchaser is of established credit, and the seller has more than enough money at command to serve his immediate needs. In such a case the purchaser should take his legitimate limit of credit. Only when the monetary consideration makes it worth his while should a purchaser pay before the account is properly due.

The Value of Cash Discounts. The vast bulk of commercial business is done by those buyers who have established themselves in the confidence of their merchants, and who run accounts varying with the respective customs of trade.

We do not at this moment dissect the body commercial and investigate the credit terms usual in the various branches of shopkeeping. We merely urge the principle which should decide the mode of payment when there is an option on the part of the debtor.

Let us assume, for the purposes of illustration, that a merchant purchases goods to the average value of £50 per month from a certain manufacturer. He runs an account which he settles regularly once in three months. These are the usual terms in the trade, recognised as convenient by both parties. But it may happen that by paying monthly the purchaser could secure 2½ per cent. higher discount. The terms

may be *net three months* and 2½ *per cent. monthly*, or 2½ *per cent. at three months' account* and 5 *per cent. monthly*. Both practices prevail in several classes of goods. In either case the man who accepts the monthly terms pays 2½ per cent. less than he who takes the full three months' terms.

In the case we selected for illustration—an account averaging £50 a month—the extra discount received during the twelvemonth would be £15. What has the buyer done to earn this money? He has merely employed £100 in what, divorced from the association which led up to it, would constitute a simple money-lending transaction. Consideration will show that more than £100 is never employed at one time. The result represents, therefore, 15 per cent. upon the money employed. This is the actual cash value of the earlier terms of payment. The case we have considered is a modest one—an account of £600 a year. If the business purchased, say, £6,000 worth of merchandise per annum, and the system of earlier payment with its accompanying higher cash discount were made to supersede the longer credit over all the accounts, the saving in hard cash would be £150 per annum.

In a modest provincial centre many businesses purchasing goods to the value of £6,000 a year are run on a rental of £150 per annum, so that in such a case the introduction of paying for higher discount will pay the rent of the premises. Even if bankers' accommodation were necessary to give the ability to adopt the system of earlier payment, and, say, 6 per cent. had to be paid for the advance, the gain would still be with the buyer. Experienced buyers are often astonished when they make a scientific examination of the subject of credit and elicit the real facts.

Laggards in Payment. The one thing the student of this course should set his face against from the beginning is the habit of the laggard in business, particularly in the matter of payment. For one who lags behind by misfortune there must, of course, be profound sympathy. Sometimes the circumstances under which he pursues his career are beyond his own control, and non-success is his misfortune and not his fault. Often, however, there is something wrong in his system of business. To the laggards who are in straitened circumstances through trading beyond their means we can only point out the risks they are running. The higher the flight the greater will be the fall; and much genuine business ability has passed through Carey Street merely through misjudging the strength of wing. When credit is always on tension, it is nearer the snapping point than when it is carrying only a normal strain. The outer side of the wall of business success is strewn with the remains of "vaulting ambition which o'erleaps itself," and is hurt by its fall. For the laggards from choice, those who can pay but who put off the hour of reckoning indefinitely or altogether, we have no word. We reserve our advice for those who are their unfortunate creditors.

Stock-keeping. The second great department of shopkeeping which we set out to discuss is stock-keeping. The general principles which ought to apply to the keeping of stock may be summarised in a few rules, upon each of which a commercial sermon might be written. Every scheme of stock-keeping should consider—

1. The accessibility of the articles.
2. Their display when desirable.
3. Their arrangement, so that when stock is low the shelves do not look unduly thin, nor when big are they confused.
4. Their arrangement so that shortages may be seen with the least possible delay and trouble, and so that stock may be taken with the least possible labour.

When a stock is large and varied, spreading itself over several warehouses or flats, its arrangement is a difficult problem. The difficulties are greatest when the business is too big to be handled conveniently as a small concern, and yet not large enough to arrange in distinct departments. An arrangement which gives immediate accessibility to stock is also difficult when the business is one in which both wholesale and retail trading are carried on and such businesses are numerous in the provinces. When the retail department is so small as to be almost negligible, and the locality not promising for its development, it may sometimes be well to leave stock keeping under the system most suitable for the wholesale trade. But where the retail side is important or deserving encouragement, separate stock for the retail trade should be kept.

Spoiled Stock. The fundamental difference between wholesale and retail stock-keeping is that in the former displayed stock is unessential, even undesirable, while in the latter open displayed stock or samples of stock are a most important factor in inducing sales. In a retail trade, further, the different articles should be stored so as to be ready at hand. The particular trade concerned, the nature of the stock, and the limitations of the business premises must determine the extent to which this ideal principle can be carried into practice.

The tarnishing of stock constitutes, in some trades, a considerable burden on the business. It arises from several causes as, for instance, the natural dampness of the premises, which will make iron and steel articles rust, brass goods become black and many fabrics rot; the too long exposure to the sun, which will spoil dyed dress stuffs, chocolate, confectionery, and many other articles of merchandise; and even the mere action of light, which will perish india-rubber. How the dead charge for loss by shop-soiling may be reduced depends entirely upon the nature of the trade. No royal receipt can be given for it. Constant vigilance and forethought must be brought to bear in attempts to keep down this charge, and, so far as concerns the general principles of the question, that is as much as can be said. Several of the cautions applying to particular departments of trade will be set down as we consider the various trades themselves.

Elasticity in Stock-keeping. In most trades there are times of the year when stock is heavy, and other periods when thin shelves are the aim of the careful buyer and stock-keeper. Particularly in those trades subject to great variation in the quantity of stock, attempts should be made to obviate the evil effects of the extremes. If accommodation be arranged on the lower basis, the periods of heavy stocks bring confusion. The shelves, bins, drawers, or other receptacles, cannot expand, and odd corners must be found for surplus stock away from goods of the same class. At the other extreme the only objection is from the point of appearance. Thin shelves have a poverty-stricken aspect that repels a customer. Even if the stock is, perforce, thin through straitened funds, it is well to disguise the fact. "Assume a virtue, if you have it not" is often a legitimate piece of counsel, and obedience to the precept a proper proceeding. The accommodation for stock should be framed on the larger scale. One may get a small boy into a man's garments, but the man cannot hide himself in the boy's clothes. *Elasticity* in any system of stock-keeping is something which should be sought. There are several means to its attainment, although every man, in applying the principle to his own needs, must be the judge of the individual factors requiring consideration.

Shop-fitting. Let us take the business of a Gentleman's Outfitter as typical. A selection of stock boxes or drawers filling the shelves is the most convenient system of stocking. It is never apparent whether the boxes are full or empty, so that the thinness of the stock is never evident when it is low, and if the boxes or drawers are numerous enough for full stocks we have elasticity to its ideal extent. The accessibility of stock, upon which we have already laid stress, is another feature of such a scheme. There are numerous other trades to which the same principle may be applied, though usually in a less degree. The draper, for instance, the ironmonger, the bootmaker, and many other shopkeepers, are modifying the shelf-arrangement by the replacement of parcels by stock boxes or drawers, and the benefits of the improvement redound upon both the purchaser and the merchant. More rapid attention may be given, a smaller number of counter salesmen is adequate, and the stock is better kept.

Selling. Among the qualifications which go to make a successful merchant that of selling is the chief. The functions of buying and of stock-keeping, however excellent in their systems and conduct, are barren of profitable result unless they are rendered complete by a successful selling department. It is easy to buy, but even if the right goods be bought at the right prices, an insufficient selling organisation will rob the buyer and the stock-keeper of the proper fruits of their labour.

Naturally every merchant desires to obtain as high prices as possible for the merchandise he handles without unduly curtailing sales. He strives to do as large a trade as he can without inviting custom by sacrificing his legitimate profit and surrendering the principles which should guide him in determining his prices.

There is greater danger in selling too cheaply than in framing prices on too high a scale. Young merchants and young firms are too often prone to "slaughter" prices, to the annoyance and loss of the competitors whose custom they are trying to alienate, and often to their own ultimate undoing. There is a limit of cheapness below which business is not worth having, and every merchant should find out where this limit is in his own case.

He should be able to tell exactly what are his *working expenses* or *dead charges*. If he buys an article at 20*s*. and sells it at 20*s*. he has not only not made a profit—he has incurred a loss. It should be an invariable rule in business that every sale should represent in profit not less than its proper proportion of working expenses. Working expenses vary in different trades. In a large grocery business they may equal only 5 per cent. of the turnover. In a small chemist's business they may be 50 per cent. And here we may consider what are working expenses.

Working Expenses. We must draw a clear line between the cost of goods and the working expenses. The former includes the money paid for the goods, the cost of carriage and of packages, and loss by deterioration. Many merchants consider as cost price only the money actually paid for merchandise, reckoning the items of carriage and deterioration loss as working expenses. This is wrong. Merchandise is often purchased carriage paid to warehouse, and other goods are bought carriage forward, the amount of carriage depending upon the nature of the goods, the classification under which they come in the Railway Companies' regulations, and the distance they are transported. To act upon the principle that this charge is a working expense is to assess twice over goods that have been purchased carriage paid, and to release from part of their proper share of the charges for transportation articles upon which carriage has been paid upon delivery. Carriage should invariably be reckoned in cost price, and for goods that are marked on the shelves or in the drawers, the carriage should be included in the cost price marked upon them and the selling price arranged with this as a basis.

Apportioning the Cost. Assume that a clothier receives a consignment of cloth, the invoice price of which is £50, and that the carriage has cost him £2. Assume, again, that the price of the cloth per yard is 4*s*. 2*d*. It has cost 2*d*. to bring each yard in the rolls of cloth to his shop, and the cloth ought to be marked as having cost 4*s*. 4*d*. per yard. The ideal system of apportioning carriage-cost should also take into consideration differences of bulk and weight in individual articles. Where the package of goods received is so mixed up the system of adding the absolutely correct proportion of carriage charge becomes impracticable. Some of the articles may be bulkier or heavier in relation to value than others and ought, therefore, to be made to carry a

larger share of the transportation charge. But to work out the proper proportion to its correct mathematical value is not possible, and it is well to treat the contents of one consignment as if the differences mentioned did not exist, and to assess each article upon the carriage expense in regard to its money value to the whole package.

We have mentioned loss by deterioration as a charge which should be reckoned in costing. This depends upon the particular trade. Where the loss by perishing, tarnishing, or going out of fashion is fairly uniform over the whole stock, it may be reckoned as a working expense. As typical of the justice of treating deterioration as part of cost price, we may instance the strawberries and other fresh fruit sometimes sold by grocers. Should a stock of this fruit be left on hand on Saturday night, it will probably be unsaleable on Monday morning. It would not be just to spread this loss over all the groceries sold. The fruit should be sold at such a price as will, after paying for the loss by perishing, leave a profit on the whole quantity of fruit sold.

Working Expenses Defined. Working expenses may be defined as the cost of running a business. They include wages of salesmen and other *employés*, rent, taxes, light, heat, paper, string, office expenses, bad debts, postages, advertising, interest on capital, and salaries of principal or partners. These last two items—interest on capital and salaries to owners—are frequently omitted from the reckoning of working expenses by private traders, but they should always be included. The money invested would, if invested elsewhere, have earned money, and the service rendered by principals in a business should also be remunerated apart from the interest upon capital.

If the business be one in which the working expenses amount to 20 per cent. of the turnover, the cost price of any article should be increased by 25 per cent. to ascertain the gross cost price—*i.e.*, total cost, including working expenses. There is frequently disaster in business from the practice of reckoning percentages upon cost at the same rates as percentages on receipts. It may be argued that the term profit correctly means profit on cost, but danger lurks in adopting cost as the basis in practice. Expenses are calculated on turnover, and the difference between a given percentage on cost and the same percentage on turnover should be clearly recognised and allowed for.

In some trades a considerable business is done in articles which are not put into stock, but are merely ordered from the manufacturers direct for customers, or sent direct to purchasers whenever they reach the merchant. These do not build up the working expenses as ordinary stock does, and it is reasonably considered that they may be sold even if the prices received for them do not represent in added profit the average proportion of working-expense charge. This practice is permissible, but it should not be indulged in except when necessity demands. In any case it must not be forgotten that the sale of such articles without the addition of the full proportions of working expenses raises the working-expense charge, which should be added to goods sold from stock in the regular way.

Selling Methods. The shopkeeper who would make his way to success must impress and attract the public, and the methods by which this is attempted are as diverse as human ingenuity can suggest. In the window of a shopkeeper in a London suburb there is prominently displayed this legend—"No order too small for our attention, none too large for our execution." This is calculated to impress the stranger, and, if the shopkeeper who exhibits it is as systematic and enterprising as the sign would lead one to suppose, his success is not a matter of doubt. The announcement is much more than merely a catchy advertisement. It expresses in thirteen words the fundamental principle of business success. The man who is "superior" to attention to small things is frequently surprised to discover that he is considered too small for big things.

The methods devised for attracting strangers to the counter include shop and window displays, price-cutting, the marking of all goods with plain figures, periodical sales, catch penny lines, press advertising, and circular distribution. Some of these subjects are so large in themselves as to deserve special treatment. Shop and window displays and advertising will be discussed at length later. The other matters we may deal with in a few words here.

Price-cutting. The practice of price cutting has become so general and so vexatious that shopkeepers have rebelled. No trade is sufficiently united to suppress it, but action in attempts to overcome the evil has been manifested in two ways. The first is *substitution*. The cutting of prices is practised chiefly in widely advertised articles of large sale—patent medicines, for instance. Substitutes as nearly as possible resembling the advertised articles are manufactured and sold instead of them whenever possible. The merchant cannot be blamed for attempting to provide substitutes provided that there is no deception practised and that the customer knows what he is buying. Both the public and the manufacturer are rather given to consider the retail trade as a philanthropic institution established for their benefit and not to yield livelihoods to its members. The other result of price-cutting is the spread of the principle of *price maintenance*. This means that manufacturers sell their specialities only on condition that a minimum selling price be maintained by distributors. Naturally, merchants encourage manufacturers to adopt price maintenance, and would be foolish in their own interests if they did not sell price-maintained articles in place of those in which there is unbridled license to cut prices.

Price-cutting is scarcely defensible. Whether it be a magazine or a box of pills, the retailer deserves his profit for the part he has played in acting as intermediary between the manufacturer and the public. Retailers suffer from cutting and retailers only are responsible for it. Unfortunately, it is the irresponsible members of the merchant class who have given the practice its strong hold.

To be continued

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M. SOLON, Manager of Minton's Potteries; and other authorities and experts

THE PLACE AND INFLUENCE OF ART IN LIFE

By P. G. Konody and Haldane Macfall

THERE is no entirely satisfactory definition of the nature of Art. Philosophers, writers on æsthetics, and art historians have tried times without number to confine its functions within narrow limits, or to express with scientific precision the essence of art in a simple phrase. Others, like Count Tolstoi, have devoted whole volumes to the question, "What is Art?" without arriving at a satisfactory conclusion.

The most widely-spread fallacies are, that art is exclusively concerned with beauty, and that it is necessarily a transcript of Nature. It is, in fact, a language for expressing human emotions, but this definition does not completely cover the ground. The creation of a true work of art entails a state of exaltation, a pleasurable thrill, in its originator—a thrill which is communicated to the beholder and produces an equally pleasurable sensation that raises his mind into spheres far beyond the matter-of-fact details of everyday life. The function of Art is, therefore, to introduce pleasure into the life of everybody, and a knowledge and appreciation of Art is necessary for the complete enjoyment of life. The more the student advances in this knowledge, the more intense will be his enjoyment.

The Language of Emotion True, much that, whilst he was in ignorance, left him unmoved, much even that he liked, will commence to jar on him; but there is ample compensation in the thrill, the incomparable delight, that results from the appreciation of true art. Thus the untrained ear may derive pleasure from the tunes of a barrel-organ. Musical education will turn this pleasure into veritable pain, but the enjoyment of a complex orchestral symphony is so immeasurably increased, that musical education becomes a very distinct advantage. The loss of enjoyment is only in quantity, the great gain in intensity. The same may be said with equal justice of painting, sculpture, poetry, or any other method of artistic expression.

If Art is defined as a language for expressing emotions, it must be borne in mind that at its best it is a vague language, a language which suggests far more than it actually says, and in consequence stimulates independent thought. Hence its educational influence. It helps us even to appreciate the beauties of Nature, and here, again, increases our powers of enjoyment. Even things ugly in themselves are glorified by the painter's emotion and selective power, and he can teach us to regard them from his point of view. And the increased appreciation of Nature reacts again upon our attitude towards the work of Art.

Art and Human Progress. It is unnecessary to enlarge upon the part played by Art in human progress. It has always had a refining influence, and it is almost impossible to imagine any great civilisation that does not tally with an equally great advance in Art. At a time when the knowledge of letters was practically confined to monks and a very small minority of students, the painted picture and the carved relief had to serve as educational instruments. The great religious truths, as well as history, were taught to the ignorant masses through the direct appeal to the eye of works of Art.

The exercise of Art is of an essentially social character. In the dark ages of the prehistoric past man made his implements for a distinctly useful, personal purpose. He embellished them by the introduction of Art in a primitive form, to please or to impress his fellow men. Thus,

Art has always been of a more abstract and ideal character than the more utilitarian pursuits of humanity, and has played an enormously important function in the development of social life and human culture.

The artist's life, compared with that of the professional man, is and must be a precarious one. But if the youth decides, with the recklessness which is the splendid courage of youth, to be an artist, who shall turn his eyes from the vision? At least, he sets foot on a career where rich men and poor start with equal chances and no favour. But if he would realise the best that is in him (and by no other means can he achieve distinction), let him at the very start set his goal before him; let his goal be high; and let him move every step of his career towards it. Let him, above all, not stumble along towards vague ends. It is necessary to have, at the very beginning, a firm grasp of what Art is; only then can we discover and practise the simplest way to create it.

The Human Need of Art. The common mind thinks of a work of art always as a picture, painted in oils, and framed in gilt. But Art is not a handsome toy for the rich to play with; it is a far wider and deeper thing than that. Art is almost as great a human need as Speech. Why the term artist has come to be associated with painting in particular it is difficult to say, since a painter is not in any way a greater creator of Art than is a sculptor or a musician, or a poet, or an architect. We have here to do with the Art which moves us through our sight, the art of painting, sculpture, architecture, and the crafts.

Whatever be his religion or his philosophy, the most interesting thing to Man is Life. The desire to know all he can know of Life is the beginning and the end of all his questionings, of all his acts, of all his adventures, of all his hopes and fears and sins—nay, beyond the very grave his eyes are fixed on everlasting Life.

The Necessity for Clearness. There are two ways in which we may know about Life. We know it by living it ourselves; we know *of* it through the experiences of others. Now it is clear that even though we should go through the most romantic and adventurous career, like a Cæsar, a Columbus, or a Napoleon, we shall not know even then, in our own selves, a hundredth part of life as it is. We can know what the rest of the world knows and feels only through some means by which men can communicate sensations; and just as the great thinker conveys his thought through language, so the artist conveys his emotions through Art. Art, then, is the means by which we transfer emotion to others.

Now, it is not enough to utter a thought to account it Speech; in order to give it forth to our fellows we must put it into such clear language as they will understand. Nor is it enough to create an emotion to account it Art; we must state it in a way that will arouse response in others, whether by the

Alinari

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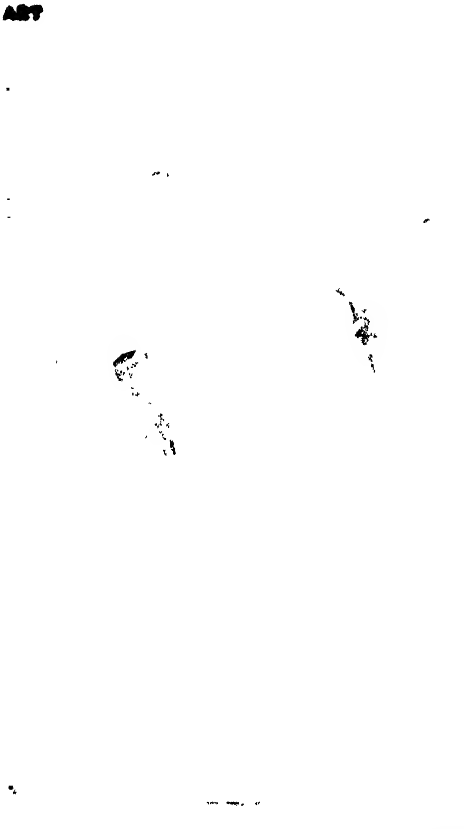


Hanfstaengl

THE MAJESTIC USE OF LINE IN ART

"Alessandro del Borro," by Velasquez, showing the use of line to give a sense of dignity

use of words in prose or verse when we call the art Poetry, or by sounds when we call it Music, or by colour when we call it Painting. Art is the language of the emotions, the vehicle by which we transfer an emotion to others, so that they feel it as we have felt it. Thus, by Art we can be made to feel fear or love or pity or hate even if we have never been brought into personal touch with some of these human sensations. When Dickens takes us through the meadows, and we walk with Little Nell, entering into the child's heart and feeling akin with her, we are experiencing real emotion conveyed by Art.

The Use of Colour. As, in music, certain sounds produce melancholy and others pleasure, so in Art we use gay colouring to give a sensation of gaiety, sombre colours to give solemnity, and so on. We can use these colours in majestic lines to give a sense of dignity, or we can use them in a demeaning way to give a sense of littleness. And thus, by using colours in their most proper way, to fit the idea we wish to express, and by using them in their most telling forms, we can paint on a canvas so that others, looking at the painting, can be made to feel the awe of a thunderstorm, the pathos of tears, the joy of the hunting-field, or the subtlest sense of the haunting sadness that lurks in the twilight.

Now, if the student has grasped the truth that Art is the Emotional Statement of Life, it will save him from two serious mistakes about which he must be very clear: Art is not Imitation but Interpretation; and there is a vast but subtle difference between Art and Craft.

We are all aware that the common mind thinks always of a work of art as being an attempt to paint things in an exact imitation, so that details in the painting "look almost as if you could pick them up."

Difference Between Art and Craft. But this realism has really little to do with Art; a photograph may do as much. It is neither for nor against its Art that the imitation should be so perfect as to deceive the eye; the artist's only concern should be that he so paints the object as to convey the general sensation that the object gave him, and the student will find early in his experience, for instance, that very often this detail and care spoil the general sense of his picture to a strange and uncanny degree, and that he has fogged the whole scheme in order to be true in little things which, at the end, have an untrue relation to each other and to the general idea. He has tried to imitate a thing instead of suggesting an impression of it.

It is important to be clear as to the difference between Art and Craft. We have seen that, as Speech is the statement of our Thoughts, Art is the statement of the Emotions. We have seen also that it is not enough to have uttered a thought to account it Speech; it is vital that the thought should be so perfectly uttered as to arouse a responsive thought in the listener.

Hanfstaengl

THE BELITTLING USE OF LINE IN ART

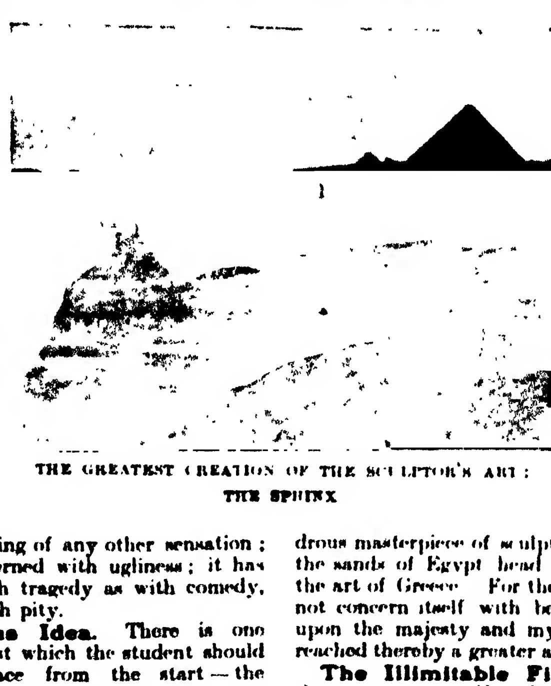
"Peasants at an Inn," by A. van Ostade, showing line used in a demeaning way, to give a sense of littleness

Otherwise we are but in a tower of Babel. And in the same way it is not enough to have uttered an emotion to account it Art; it is vital that the emotion should be so uttered as to arouse a responsive emotion in the onlooker. And, just as thought is the more easily understood the more simply it is expressed, so the emotion most simply expressed is the most likely to have its effect.

Mastery over Tools. This perfection, or beauty of handling, by which Art is expressed, we call Craftsmanship. It must be abundantly clear that the greater mastery the student acquires over the tools of his craft the more easily and the more beautifully will he be able to express the emotions, whereby he will create a work of art. Still, he must never forget that this beauty of handling, which is craftsmanship, is not anything else but craftsmanship, and has not produced Art of itself. Art *must* create; it must transfer the impression of a sensation or an emotion to others. A woman may be very beautiful; she is not Art. Beauty is not Art, nor Art beauty. But a painter may paint a beautiful woman so that her picture affects us emotionally with the same sense of charm as the woman herself; then his painting is a work of art. Craft, let us understand, is that beauty of treatment which creates a work of art, but Art itself is not necessarily the creating of the sense of beauty any more than the creating of any other sensation; it is as much concerned with ugliness; it has as much to do with tragedy as with comedy, with laughter as with pity.

A Mischievous Idea. There is one great blunder against which the student should sternly set his face from the start — the widespread and mischievous idea that Art is a luxury and only for the rich, that the rich and the elaborately educated have some peculiar understanding of Art that is denied to the ordinary person. Art is not a luxury; it is a need of the human being, and only in proportion as Art is simple and large and widespread in its appeal can it be great and far-reaching. Let us take the art of words, and the best known example of it in the world. The parables of Jesus are among the noblest works of art—their appeal comes to the prince and the peasant—nay, to the very child. We are swayed, indeed, a dozen times in the day by our emotions and instincts, as against a single act springing from our reason. The power of Art is prodigious compared with the power of reason. Let us take another example from the art of words. If a writer conveys to the world a thought, such as that "sailors and fishermen, being by their calling in near relation to the powers and mysteries of Nature, are impressed with the works of the Creator," he gives utterance to a plain fact which leaves the world cold, and is narrow in its appeal compared with the statement of the same fact stated in a picture which reaches us through the emotions in the beautiful passage: "They that go down to the sea in ships, that do business in great waters; these see the works of the Lord and His wonders in the deep." Here the solemn use of the words seems to conjure up into the senses, as at the stroke of a magician's wand, the mystery and fragrance of the sea and the seaman's calling.

The Province of Art. Schools and cliques have tried to narrow the province of Art; but the student must beware that the province of Art is as vast as life, whose servant she is. The Greeks set up beauty as the ultimate goal of Art; they really meant that the sole object of Art was to create beauty. In sculpture Greece carried this idea as far as human power could take it, yet whilst she created supreme beauty in the human form, splendid as was her achievement, she never reached to the majesty and the grandeur of the Sphinx, the wondrous masterpiece of sculpture which stands on the sands of Egypt head and shoulders above the art of Greece. For the genius of Egypt did not concern itself with beauty; it spent itself upon the majesty and mystery of life, and it reached thereby a greater and more majestic art.



THE GREATEST CREATION OF THE SCULPTOR'S ART: THE SPHINX

The Illimitable Field of Art. Art, then, concerns itself with the tears and ugliness and the greynesses of life as much as with laughter and beauty. There is no limit to human emotions; there is no limit, therefore, to Art. The higher and nobler and more sublime the emotions created by the artist, the higher and nobler and more sublime will be his art. Shakespeare sounded the wide gamut of the emotions, from the heroic ambitions of man to his most contemptible jealousies; he reached to the topmost heights of Art. What Shakespeare did in the art of words a painter may some day do in the art of colour. It is well for the student to search the schools and styles of painting for the beauty of craftsmanship whereby he may give

THE GREEK IDEAL OF BEAUTY: TWO EXAMPLES IN SCULPTURE

utterance to his art and bring cunning to his craft; but he must always remember that mere beauty of painting will not raise him to high achievement in art; it is only as he succeeds in setting on canvas the sensations Nature arouses in him in all her varying moods that he may hope for name and fame in the years to come.

No school of painters is wholly right; none wholly wrong. Art is no narrow garden to be fenced round with little hedges of style, but a vast realm of the imagination; and whether the artist attempt to give utterance to the great emotions that awake him to the majesty of life, or whether he is happier in the tender moods that arise like ghostly whispers amid the misty reaches of the river at twilight, when the factory wharf and dingy warehouse of the workaday world change into a way of fairy palaces in a mystic city; whether he be more delighted to give utterance to the heroic emotions or is more stirred by the beauty of women or the tender charm of childhood—he is an artist indeed who does any of these things exquisitely or well, so that when we look upon his work we are moved by the emotion he saw and felt, which he thrusts by his skill into our understanding.

Let the student take this most serious fact to heart. The schools are teeming with young men and with young women who have gone into them with a vague notion that at the end of three or four years they will emerge fully-fledged artists, just as our universities and hospitals turn out men equipped for the professions. The result is that for one man who becomes an artist a dozen sink in the flood of heart-breaking failures. The schools can give us training in the craftsmanship of Art, and they do it well though it is a nice question whether the student cannot learn as much by his unaided study. But whether he go through the schools or not he cannot be an artist until the day that he creates—until the day he shows us how he sees life through his own eyes. No tricks of thumb, no scraps from the old masters, will make him a master. He must have something to say that he can put into the sensitive vision of his fellow men.

To be continued

THE DRESSMAKER'S ACCESSORIES & MATERIALS

The Articles required for the Dressmaker's Complete Outfit. Materials and Quantities. Drafting Bodice, Sleeve and Collar

By AZELINE LEWIS

THE articles required for a dressmaker's outfit are:

SEWING COTTON. A good make is needed for machine and hand work. Nos 24, 30, 40, 50, and 60 will be required in black and white.

SILK. For ornamental stitching and machine work. This should be firm and good, and about 1½*d*. a reel is the price to give

TACKING COTTON AND TAPE MEASURE.

TAILOR'S CHALK. For marking seams.

TWIST. For buttonholes to match the material, for fixing bones and steels into position by fan-stitching, cross-stitching on bands, etc That sold on reels is good for buttonholes

NEEDLES. From 5 to 9 are useful numbers for all kinds of work connected with dressmaking. No. 4 "Betweens" for boning.

HOOKS AND EYES. These are required of various kinds and sizes for fastening fronts of bodices. Small mantle hooks are used for waistbands. These, like all other accessories, should be good, as those sold in cheap packets are almost invariably useless

HOOKS AND BARS. These are sometimes preferred to hooks and eyes, as the bars are easily put on. They should be buttonholed over with silk, so as not to show when the bodice is fastened

PLACKET FASTENERS. These are small spring fasteners for placket openings in various makes Small spring hooks and rings or silk loops are, however, preferred by many good dressmakers and tailors, as they are neater and less noticeable than the former.

PINS. Get good ones—short whites are the best. Steel pins or lillikins are required for velvet.

THIMBLE. Whatever this be made of it is necessary the indentations should not be too shallow, as if so the needle will be constantly slipping.

SCISSORS. Large for cutting out, and small sharp-pointed ones for buttonholes. A good pair of nail scissors will do for the latter purpose, if a punch be used for the hole.

ROLLER. For pressing seams and sleeves. A cricket bat, round stick, or rolling-pin, of ash or beech, will do for the purpose if covered.

SINGLE TRACING WHEEL. For marking out seams.

SKIRT BOARD. For tacking skirt lining and material together, pressing seams, etc.

FLAT-IRONS AND IRONING BLANKET, IRON-STAND AND HOLDER. For pressing generally.

SEWING-MACHINE. See Part I.

PUNCH OR STILETTO, for buttonholes. If buttonhole scissors are not used, one of these is necessary. For the punch have No. 5 point.

BELTINGS For the tight inside band of bodice, either single belting, webbing, or satin faced belting is used. For skirt bands, single or double Petersham, wide or narrow, shaped or straight, and satin faced belting may be used

LUTE RIBBON of various widths for lining waistband, neatening turnings, etc.

PRUSSIAN BINDING, OR GALOON. For bone casings, skirt loops, &c

WHALEBONE, BALEINETTE, FEATHERBONE, BONE, OR COVERED STEELS For stiffening seams of bodices, and so preventing wrinkles Whalebone and featherbone are somewhat expensive, but, of course, are the best, as they are more pliable and give to the figure, although the substitutes may be made to do good service if properly prepared Steels are much used, as they are easier to put in.

EDGE BONE This is very narrow, and is used for evening or laced bodices, and edge-to-edge fastenings.

SKIRT BINDING. There are many makes for this purpose, but braid, bias Velutina or brush binding are the most used The latter is perhaps the best, and it can be had in almost any colour It wears well, and dirt does not cling to it as to braid

BUCKLES. For the tight skirt bands, instead of hooks and eyes, if preferred Their use, however, is a matter of taste

A DRESS STAND A dress or bodice and skirt stand, while desirable in the case of the home worker, is quite necessary to a dressmaker's outfit. The expanding dress and bodice stands are the best for the latter, but are somewhat expensive The home worker, however, can make herself an efficient substitute for a bodice-stand out of a discarded bodice, or even a bodice lining which fits well. See that the seams are firmly stitched up, close fronts together securely after having removed all buttons or anything likely to make a ridge, sew a piece round neck opening, and proceed to stuff the inside thus made till it is firm and well filled A stick of the right length for the middle will make it stand better. Sew a piece of cloth or material firmly to the bottom and then close armhole. The sleeve can also be stuffed in the same way, and will be found useful and helpful as an arm-stand for ascertaining the length and fit of a sleeve, especially if gathered, puffed, or of the ornamental kind now so fashionable, and as sleeves alter so constantly, it is well to be prepared to meet the changes.

DRESS-PRESERVERS. These will also be needed, whilst a pinking outfit can be added, but, though useful, it is not an absolute necessity.

Materials. The materials of the dressmaker are so many that a full list is impossible, but the following is a fair average of the widths of those most in use:

Serge, Frieze, Cashmere, Voile, and double-width goods, 44 to 48 inches in width.

Fine-faced Cloth, 48 to 54 inches.

Fancy Flannels, Delaine and such-like goods, 27 inches.

Plain Silk, 22 inches.

Washing, or Pongee Silk, 27 to 36 inches.

Silk (very good makes), 42 inches.

Prints and Cotton goods, 27 inches.

Ordinary Satin, 22 inches, but some makes for mantles, etc., are double width.

Liberty Satin averages 48 to 50 inches.

Velveteen, 24 to 27 inches.

Velvet (ordinary for trimmings, etc.), 18 to 22 inches.

Linings. Linings should be good. It is not worth while making up a bodice on a poor foundation, as this stretches and loses its shape, and will never be satisfactory. In this section of dressmaking, however, as in materials, fashion has to be studied, and of late the special makes of sateen are largely used for both bodice and skirt linings. These are now known under various names, such as Roman Satin, etc.

The linings which are most commonly used, and which are recommended for wear, are:

BODICE LININGS.

For Serge materials: good Silesia, 36 inches.

For Print or Cotton: Calico or Silesia, do.

For Cloth: Sateen, 30 inches, or Italian Cloth, 54 inches.

For Muslin, Delaine: Sateen or Cambric.

For Silk or Satin: Silk is best to use, but the better makes of Sateen or fancy Sateen, if good, will do equally well. For light materials the light backs should be used, and for dark goods black or dark backs, according to the colour.

SKIRT LININGS.

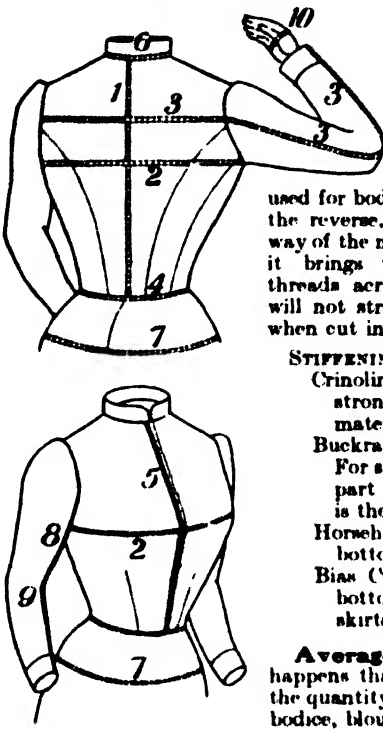
For Serge: Linenette, Sateen, or Alpaca.

For Velveteen: Alpaca, or silk-finished Linenette.

For Silk: Sateen, Silkette, or any other corresponding make.

For Cloth: Italian Cloth.

The question of skirt lining is, of course, one that is answered more or less by Dame Fashion. Sometimes the skirts are lined throughout; then, again, she decrees that they shall be made on a separate foundation, secured to the skirt at waist. For transparent materials, voile, and such-like goods, the latter is by far the most effective. Cloth and other materials may be unlined, but in the latter case many tailors and dressmakers prefer to line the front width. Some materials, like silks and good woollens, should be cut somewhat larger than the lining, as they shrink slightly when cut. Ordinary sateen, if used for bodice lining, should be cut the reverse, and not the selvedge way of the material, as by so cutting it brings the selvedge or warp threads across the pattern, and it will not stretch quite so much as when cut in the usual way.



19. BODICE MEASUREMENTS

STIFFENING MATERIALS.

Crinoline Muslin: A coarse, strong muslin for washing materials.

Buckram and Tailor's Canvas: For stiffening collars and cuff part of sleeves. The latter is the most used.

Horsehair Cloth: For skirt bottoms.

Bias Crinolette: For stiffening bottoms of dress and underskirts according to fashion.

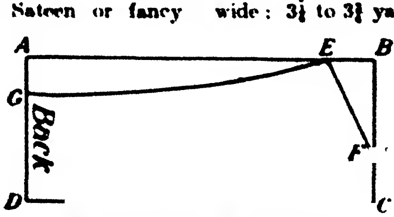
Average Quantities. It often happens that a dressmaker is asked the quantity required for a costume, bodice, blouse, etc., and the following list of quantities required for the *plainer* garments may be found useful to the beginner:

For a plain dress of print, 27 inches wide: 10 yards.

Cashmere and double-width goods: 6 yards.

30 and 36 inch material: 9 yards.

For a plain walking skirt of material 44 inches wide: 3¼ to 3¾ yards.



20. COLLAR MEASUREMENTS

Circular skirts, 48-inch goods: 3 yards.

Pleated skirts, 3½ to 4 yards.

Bodice with basque, medium size: 2 to 2¼ yards of double width material.

Bodice without basque: 1¾ yards.

Bodice lining, 36 inches wide: 1½ to 2 yards.

Plain shirt-blouse, 27-inch material: 3 yards.

Blouse with full sleeves, 22 or 27 inches wide material: 3½ to 4 yards.

Gathered with full do., do.: 4 to 5 yards.

Eton coat, do.: 1½ yards.

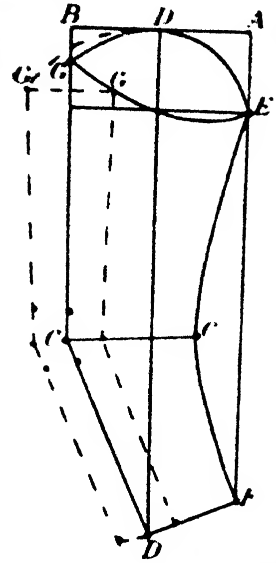
Russian blouse, or coatee, do.: 2¾ yards.

NOTE. Materials with an up and down,

either of pile or pattern, cannot be used as economically as those without, as the pattern cannot be reversed, and each piece must be the right way up of the material. In the case of velvet or velveteen even more must be allowed, as each piece must be cut separately. This last, however, is fully shown in a later diagram.

FRILLS AND FLOUNCES will add to the quantities given above for skirts, these depending on the number, style, and width of same.

For Kilting about three times the width of skirt is usually allowed, and as this is cut on the straight, the necessary addition is easily arrived at in this way. If a four-inch wide kilt is to be the ornamentation, there would be nine strips to the yard, giving about 10½ yards for kilting, and the width of the skirt will decide whether this is too much or too little.



21 DRAFTING THE SLEEVE

Gathered Frills are a little more difficult of calculation, as these are cut on the cross, but 27 inch goods will give a crossway strip of about one yard across the full width. The corners, however, can all be used, but the shorter lengths should be joined in with the longer ones, so as to avoid many seams coming together.

For Crossway Frills one and a half to twice the width of the skirt is usually allowed. The quantity, however, depends very much on the material used, and for thin or flimsy stuff even more may be allowed.

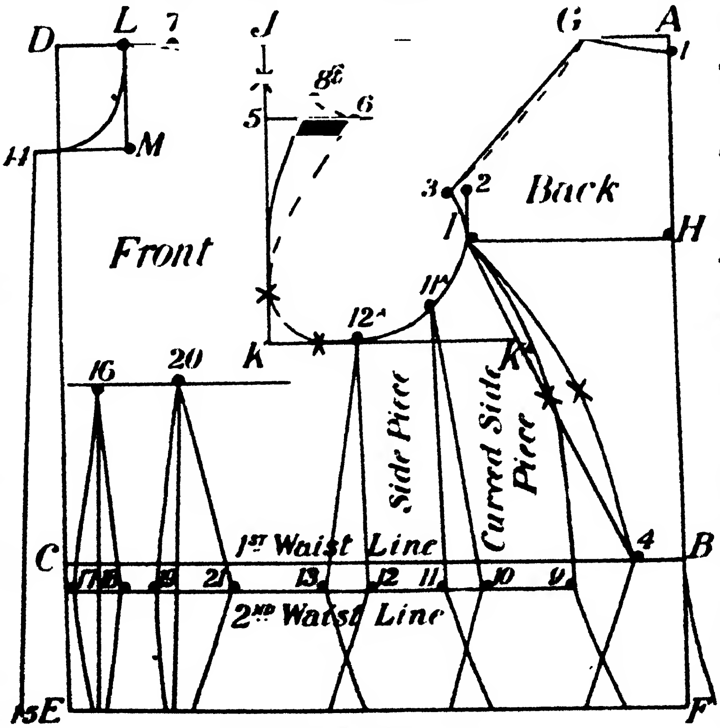
For Box Pleating, about three times, and for Double Box Pleating, four times the width of skirt is the usual allowance.

The Balayeuse, or silk frill, is generally cut on the cross and gathered. If straight it is kilted, the edges being pinked in either case. If kilted, it is cut on the straight of the material, the make of the latter deciding whether it should be cut selvedge ways or across, but it usually wears out quicker if cut the former way. About two yards of silk will make a crossway frill five inches wide for a skirt three and a half to four yards round. In this every little bit of the silk can be used.

When all the pieces are joined, unite the whole in a circle, being careful it is not twisted and that all seams are on the wrong side. Press them, fold in four, and tack the four thicknesses together. See that all the edges are perfectly even, cutting off unevennesses; it can then be pinked at a charge of about 1d. for three yards. Undertakers usually do this, but it can be done at home with the necessary tools.

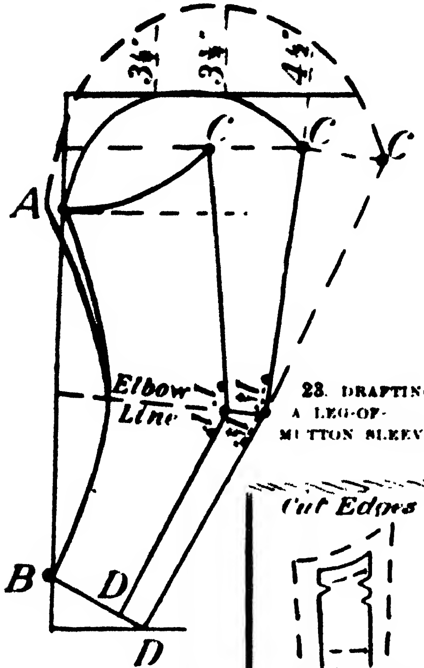
Drafting of Bodice, Sleeve, and Collar. It is so easy nowadays to buy a pattern of any size, or to get one cut, that many know nothing whatever about drafting one from measurements, but the ability to do so is almost essential to anyone aspiring to a proper knowledge of dressmaking.

There are many systems of bodice drafting, but the following is adapted from a French one, which we have found to answer perfectly, both in cut and fit, with



22. DRAFTING THE BODICE

the additional advantage of being easy to understand. It is based on the following proportional divisions of *half* the bust measure-



23. DRAFTING A LEG-OF-MUTTON SLEEVE

ment, viz.: *half*, *one-third*, *two-thirds*, *one sixth*, and *one-twelfth*, the others being needed to obtain correctness of outline and fit.

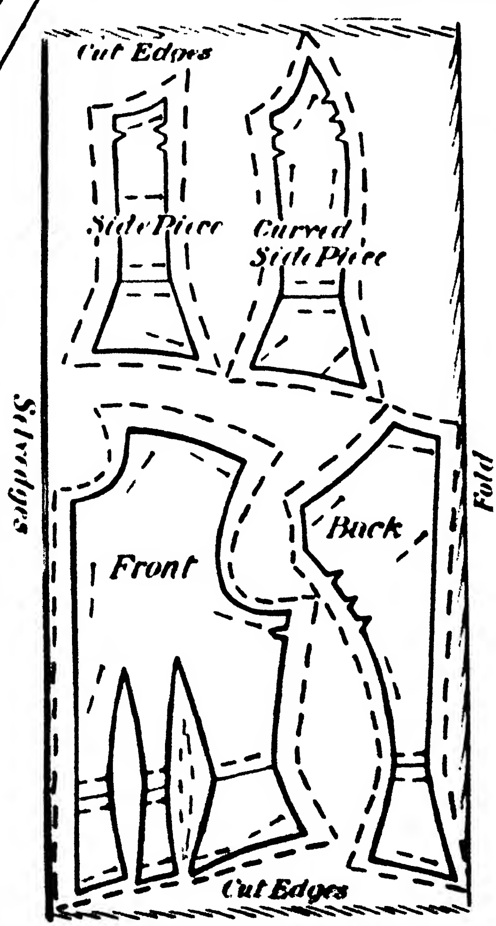
Very few figures, however, are absolutely symmetrical, the Juno-like type existing more often in the halls of statuary, or in an artist's imagination than in real life; but the deviations from the above proportions of the measurements, which in most cases should be very slight, are easily ascertained and arranged for In this shape the back edge of the second dart comes more or less on the cross, the difference being clearly seen in diagram 26. [See also TAILORING.]

A good dressmaker, however, whether amateur or professional, should study well the figure she has to deal with, so as to note any peculiarities which may assist her in drafting and cutting out a bodice, either from measurement or from a pattern, and so do much towards obtaining that desire of a modiste, "a perfect fit."

The Measurements. For this system the following are needed:

1. Length of Back.
2. Bust measure.
3. Width of Back, continuing measure to elbow, thence to wrist (the two last are for sleeve).
4. Size of Waist.
5. Length of Front to Waist, also marking Bust line.
6. Neck measurement.
7. Hip measurement.
8. Length of Front Seam of Sleeve.
9. Size of Elbow.
10. Size of Hand (closed).

The two first may be called the primary or essential measurements, as within the rectangle formed by them the bodice is drafted.



24. CUTTING OUT THE LINING

Take these measures, as shown in the accompanying diagram [19]. No. 2 should be taken rather loosely, No. 4 closely. No. 6 should be easy. To get the waist-line, fix a tape (or a second measure) securely round the waist, when it will fall naturally into the proper line, and will thus give a definite measure for Nos. 1 and 5, which are both very important, and the average eye is not reliable enough to be trusted for the purpose.

Before proceeding with the drafting, have the measurements clearly written out for reference, also the various divisions of the bust measure under consideration.

The bodice in the diagram [19] was drafted to an 18-inch measurement, the necessary divisions of which for drafting and explanatory purposes are — $\frac{1}{2}$ = 9 inches; $\frac{1}{3}$ = 6 inches; $\frac{2}{3}$ = 12 inches; $\frac{1}{6}$ = 3 inches; and $\frac{1}{12}$ = $1\frac{1}{2}$ inches.

Remember only *half* the bust measure is used, as only half the bodice is drafted. The above would, therefore, mean a 36-inch full bust

measure. Half the waist and neck measures also would be used, but the full length of back must be taken, as will readily be understood.

The Drafting. In the following drafting the proportional lines are marked in their alphabetical sequence; those for the shaping of the bodice are numbered in the order in which they should be taken and drawn [22].

Lines *A-B* and *C-D* are formed by length of back, plus half an inch for neck curve of back.

A-D and *B-C* are each half bust measure.

B-F and *C-E*: Length of basque.

The length of the last lines depends entirely on taste and fashion.

B-C: Waist line.

A-H and *H-I* are each $\frac{1}{8}$ of bust measure.

A-J, $\frac{3}{8}$ of do.

J-K, $\frac{1}{8}$ of do.

L-M, $\frac{1}{8}$ of do.

The last, however, should not be drawn till the front shoulder is done, as it is determined by the position of this.

A-G, $\frac{1}{6}$ of bust measure, less $\frac{1}{4}$ an inch to allow for curve.

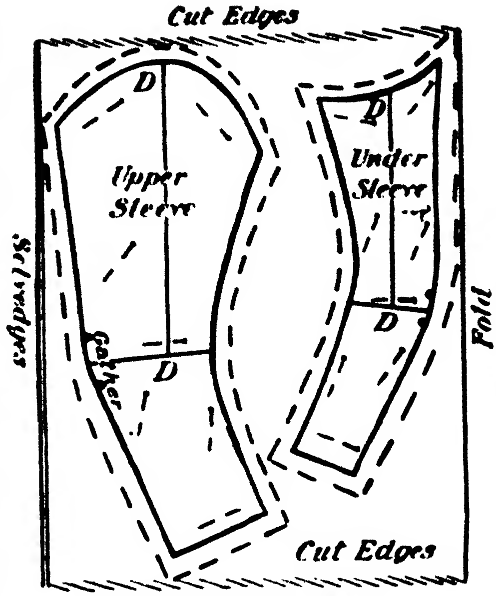
A-1 is $\frac{1}{2}$ an inch.

H to *I*: Width of back ($\frac{1}{8}$ of bust measure).

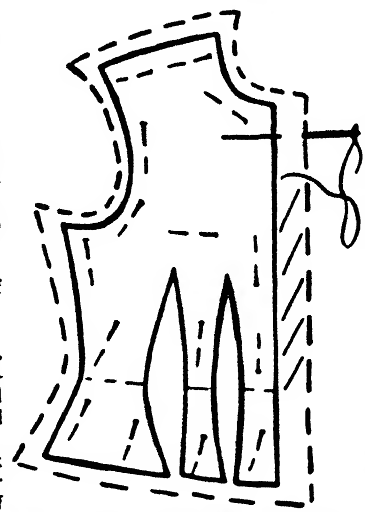
I-2 is $1\frac{1}{2}$ inch.

This measure, however, varies, according to the dictates of fashion with regard to long or high-shouldered effects.

2-3 is $\frac{1}{2}$ an inch; draw back curve, then from 3-*G* for shoulder (hollow this out $\frac{1}{4}$ of an inch afterwards, as shown by the broken line).



25. CUTTING THE SLEEVE



26. BASTING LINING AND MATERIAL TOGETHER

B-4 is $1\frac{1}{2}$ inch; mark this and draw *I-4*. Measure 1 inch in centre of this to the right (to assist in drawing back curve). Draw back from *I-4*, curving through mark just made in centre, as indicated by the cross.

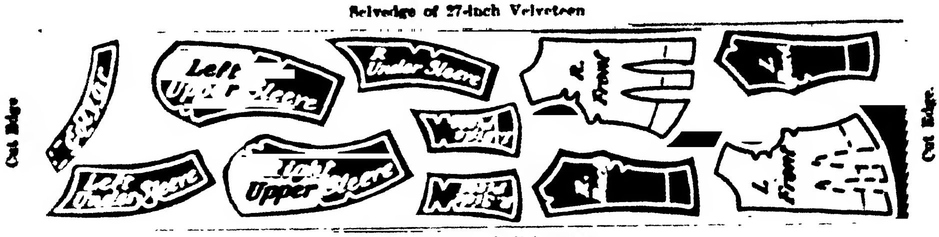
Front Shoulder and Armhole. *J-5* is $\frac{3}{4}$ of an inch longer than *I-2*, the exact centre being marked by a X; 5-6 is drawn at right angles to give the shoulder-line of front. Draw 6-7 $\frac{1}{4}$ of an inch less than 3-*G*, placing the centre on the mark in that of *J-7*.

The front shoulder-line should always be less than the back, as it must be stretched to this; in some cases it can be $\frac{1}{2}$ of an inch less than back.

At angle formed by *K* and *K*^{a}, mark $\frac{1}{16}$ of bust measure (this is merely to assist in obtaining armhole curve). Form armhole from 6-3, passing through marks made in angle *K* and *K*^{a}, rounding well as it approaches back curve so as to continue this.

4-9 is 2 inches, the amount to be suppressed at waist between back and side body. Mark this on first waist-line, then curve from *I-9*, taking it $\frac{1}{4}$ of an inch to right of line *I-4*, and pass through this opposite the centre marked by a X. (The curve at upper part thus given will allow room for shoulder blade, and enable the side-piece to fit easily and to set closely at the armhole.)

Selvedge of 27-inch Velveteen



Selvedge of 27-inch Velveteen

27. CUTTING OUT BODICE AND SLEEVES

Now advance front shoulder from 6-8 and 7-[illegible] of bust measure in each case; round this slightly, and draw front portion of armhole from 6 to line *J—K* as indicated by a firm and not a broken line.

This advance of shoulder-line gives the requisite pitch forward to throw the back dart on the cross.

From *L* draw *M* (1/4 of bust measure), and from this draw another line at right angles to meet line *D–C*. In the rectangle thus formed draw front neck.

The Side Pieces. To obtain 2nd waist-line, lower 9 3/4 of an inch below *B–C*, measure length of front, from neck mark this, also bust line; on line *D–C* draw real waist-line from 9 to length of front just marked.

This lowering of waist line is to allow for the inch taken out in back curve, and to bring it up to waist line of this.

On this 2nd waist line mark 9-10, 11-12; and 13 for side-pieces. 9 10 may vary from 2 1/2 to 4 inches, according to size of waist; in the case of larger sizes, however, it is better to have three smaller side pieces than two very large ones. [See Large Size Bodice.] 11-12 should always measure 1/2 an inch less than 9 10, 10-11 and 12 13 each measure 1 inch for waist suppression. Draw 11 11[a] and 12 12[a] before 10 11[a] and 13. The reason for this is that the under arm piece should be straight, and it is easier to get the right inclination of the other lines by so doing.

Front-fitting Line and Darts. Measure neck and bust, and add on in front the amount taken in side pieces and back (usually from 1 to 1 1/2 inches), and draw 14-15 for front fitting line. Be careful not to "bow" this out at the bust, nor make it tight. For the darts, measure from *B* 4, *9-10, 11 12,* and *13-C*, subtract half the waist measure (remember, only half the measures are used) from this, when the remainder will have to be suppressed in the darts. Mark 16, which may vary from 2 to 2 1/2 inches from front fitting line, draw line for centre, then mark 17 and 18 at equal distances on either side and draw these lines. (From 1 to 1 1/2 inches is the average amount to be taken in this dart, which is always the smaller of the two.)

For back dart mark 19 1 inch to right of 18, then 20 on bust line, which may be from 1 1/2 to 2 1/2 inches from top of front dart. Measure and mark off amount to be taken in back dart on waist line, and draw 20-21. (Remember, in this cut of bodice the front edge of back dart should be nearly straight, and the back edge almost, if not quite, on the cross.) The back dart also is always the higher of the two.

Now divide and add on the superfluous inches of hip measure equally on the various basque portions, and draw these as sketched.

Lastly, go over the measurements carefully, compare them all with those taken, and make any alterations necessary before tracing and cutting out.

The under-arm piece may be traced out separately, to avoid cutting off the basques of front and curved side-piece, or if not, piece must be joined on exactly the same as those cut off.

NOTE: If the worker be familiar with the French metre, she can use this for this system counting by centimetres instead of inches.

The Collar [20].

A–B; *C* and *D* are formed by size of neck at lower part.

A–D and *B–C* each measure 3 inches.

A–E, size of neck for top of collar.

G–D, 2 inches.

E–F the same.

The depth of collar, however, varies with the length of neck.

The Sleeve. Line *A–B* is 1/2 of bust measure less 1/2 of an inch (this will be taken up by the curve) [21].

B–C is length of sleeve, from width of back to elbow [see diagram 19].

D–D, midway between *A–B*, is entire length of sleeve.

A–E is 4 inches, *B–G* 1 1/2 inches.

E–F, length of front seam.

C–C, size of elbow.

The above drafting gives a plain coat sleeve, which is the foundation of all other sleeves, and from which any kind of shape can be evolved. The under-sleeve can be any size desired, provided the amount taken from this be added to the upper sleeve, or in proportion as fulness may be required at the shoulder part. This is indicated by the broken lines, whilst the next diagram [23] shows the evolution of a "gigot," or leg of mutton sleeve, from the last shape indicated.

Making the Bodice. Having thus reviewed the preliminaries, the stitches, the *materials, and their uses, the method of obtaining a pattern from measurement,* we will now turn to the more interesting side, that of dressmaking pure and simple. We have chosen a dressmaker's bodice to begin with, rather than a blouse, because it may be described as the basis of a sartorial education.

Cutting Out the Lining. Before placing the pattern in position, press out all creases in the lining with a warm iron. Now arrange the various portions of the bodice pattern just drafted and cut out to the best advantage on the lining, which should be double [24]. Allow for the turnings 1 inch on the shoulders and under arm seams, and from 1/2 to 3/4 of an inch on all others for alterations. Curve the neck and shoulder outwards to allow of possible alterations here. The front fitting line must be placed 1 1/2 inches from the selvedge and even with this. Place all waist lines, except those of front, on the straight of the material, then pin the pattern to lining. Trace the waist lines carefully, also the bust line, front fitting line, darts and inset mark. Keep the lining and drafting quite smooth, then trace all round the outline of the pattern with a backward and forward movement. Remove pattern and pin together before cutting out to prevent slipping.

Place the drafting of upper and under part of sleeve on the lining with line *D* on the straight of this, trace through the elbow line and all round the pencil marks; also line *D*, leaving 1 inch all round for turning and alterations. Pin the linings together before cutting out [25].

Cutting Out the Bodice and Sleeves. Double width material should be kept folded as when bought; single widths, varying from 27 inches to 30 inches, should be folded selvedge to selvedge. Faced cloth, with the nap running downwards, satin, velvet, and velveteen (with the pile running upwards) require each piece cut separately, the same way as the pile [27]. Place the lining pattern on the material, arranging the pieces carefully. Pin in position, keeping the waist lines of back and curved side pieces on the straight of the material, and the selvedge of the lining of the bodice front to the selvedge of the material. Then cut out the same as the lining.

Basting Lining and Material Together. Great care must be exercised in basting; if this is imperfectly or carelessly done, the fit of the bodice will be impaired. Place right material front on its corresponding piece of lining, stretching the material slightly across the waist line of the lining; pin above and below this, turn over, and with a coloured cotton run lining and material together at the waist line. Turn it over so that the material is uppermost; take the pins out and place a weight (a flat iron will do) on the bodice just below the waist line; smooth up towards the shoulders and pin in position, then smooth across the bodice towards the front fitting line, also towards the outer seams. Pin again here and there, the lining to be loose and the material tight. See that the latter is quite smooth at the neck and armhole.

Move the iron as required. Baste up from the waist line, with a stitch ½ inch in length, outside the front fitting line towards the neck, outside the shoulder line, armhole-curve and down to the waist line [26]. Remove the iron and baste the basque below the waist line, keeping the lining and material smoothly together. Place the iron on the bust line, and with the fingers on the lining and thumb on the material, ease the lining into the material at that part, and tack down the centre of each dart.

Treat the left side of the bodice in exactly the same fashion, beginning the basting at the waist line of the under-arm seam and continuing right round the armhole, shoulder, neck line, outside the fitting line, and terminating at the waist line. Proceed with the basque and the darts in the same manner as the right front. The other parts of the bodice are pinned, arranged, and basted in the same way, taking great care not to stretch either the curved side pieces or the curved side of back.

Outline with coloured cotton all waist lines, front fitting lines, neck line, armhole curve, inset mark, elbow and wrist lines of sleeve. In basting the sleeve take care not to stretch the material.

Tacking. Pin the various portions together with fine pins, removing these as the bodice is tacked. Start with the centre back pieces; place the waist lines even and beginning from there, tack up to the neck, then from waist line to the edge of the basque (using small stitches), and always putting a double stitch at the waist line to hold it firmly. Be sure and tack in the wheel-marks or the bodice will be too large.

Next take the curved side-pieces and tack these to the corresponding part of back, starting this from the waist line as before. The curved portion of this can be very slightly eased by holding this part over the hand when tacking together to set smoothly with the corresponding part of back. The armhole lines should meet all round. Now join the under-arm pieces to the curved side-pieces, also the fronts at the under-arm and shoulder seams. When joining the shoulder seams, begin at the neck and slightly stretch the *front* to the *back* shoulder. Tack down the darts, starting at the top and working towards the basque.

Note. *If the darts are cut on the French system, the back one will have to be cut before tacking together, allowing ½ inch turnings. Be careful that the point is even, and stretch the back edge a little to the front, which, being very nearly straight, allows this to be done.*

To be continued

THE OFFICE BOY WITH A FUTURE

The Beginnings of a Commercial Career. First Steps in all Departments. Correspondence. Telephone. Simple Book-keeping.

By A. J. WINDUS

Concerning Lady Clerks. Commercial life, in its modern developments, offers many careers for women, though, fortunately, the economic conditions which have forced women into business competition with men have not lowered the average age at which young ladies enter the arena to that of the office boy. A boy usually passes straight from school to commercial life, whereas a girl on leaving school generally allows two or three years to elapse before seeking a situation in an office. This interval will have its duties, its devotions and its recreations, but time must be found for study also.

The field for lady clerks is an ever-widening one, but we may sum up the attainments required of them thus: Shorthand, typewriting, commercial correspondence, modern languages, double entry bookkeeping, acting as desk cashier. Other sections of this work are appropriated to the study of the three first-named subjects, but this is concerned almost immediately with double entry bookkeeping, a knowledge of which is becoming more and more of a necessity to the feminine applicant for a business post. When, in addition, she is able to take down shorthand notes from dictation, and therefrom produce a typewritten letter in French or German, it is easy to see that she is in a much better position to command a satisfactory price for her labour than her less studious sister.

The Boy's Career. We come now to deal with the boy about to leave school, who contemplates with mingled hopes and fears a career in commerce. It would be well for him at this stage to try and make sure that he has the qualifications essential to success. In the first place, is he fond of study, and especially of arithmetic, geography, composition, mental arithmetic and handwriting? Is he willing to recognise the fact that his education, so far from being completed, has only just begun, and that the experience of business he will gain by practice must be supplemented by the theory to be learned from text-books and professors?

Again, a youth should consider the direction of his own inclinations, and the nature of any talent his youthful modesty may have allowed him to discover. If the carpenter's bench possess more attraction for him than the office stool, let him not be ashamed to say so now; otherwise the day may come when he will curse the false pride which kept him silent. This warning is the more necessary because many boys make their choice of a career solely on the ground that it is one which has been adopted by a friend who has left school a few months previously. The best of friends may have very different tastes, and so a lad of a free, roving nature may become tied to a sedentary occupation in which his chances of success and contentment are small.

Attention must be paid also to the matter of health. This, no doubt, is a question rather for parents; but an intelligent boy should use some discretion in the matter, and it may here be said that he should endeavour, by taking exercise in the fresh air as much as possible, by regular and correct habits, and by having good and sufficient meals, to maintain and indeed to improve his health. Again, a reasonable ambition is most essential. It will show itself in a persevering desire for improvement in attainments as well as in position. It will concern itself not with short hours and large salary, but with moral worth and business capability. Lastly, to ensure success, a boy should have laid the foundations of a good character. This he will have to build up as the years go on, and he may be assured that, in spite of any contrary assertion, a reputation for integrity, fairness, and attention to duty will stand him in good stead.

The Boy Clerk. Assuming that he has decided upon his vocation, and upon the nature of the business he wishes to enter (in regard to which circumstances will probably limit his choice), the intending clerk must seek an opening with a good firm. Possibly this may be obtained for him through the influence of his father, an adult friend, or a teacher. Failing such help, the advertisement columns of a newspaper should be studied, and written application made in likely cases, while letters may also be sent to local firms in view of a vacancy occurring. Great care should be taken with letters as to the writing, the composition and the spelling. Boys are apt to make mistakes in the last-named which they could easily avoid even without consulting a dictionary. Mention should be made of any public examinations the applicant has passed, such as University Locals, Society of Arts, Scotch Leaving Certificate, College of Preceptors, L.C.C. certificate, etc., and copies of testimonials from schoolmasters or others enclosed.

Some little time may elapse before a situation is found. In the interval a candidate should endeavour to continue his education, especially taking pains to make up leeway in any particular branch. If he already knows a little shorthand, this should be regularly practised. Attendance at a "business college" is not recommended at this stage, but the opportunities for improvement afforded by the evening continuation schools and other evening classes should be taken advantage of. A good style of hand-

writing should be striven for: that known as the Civil Service hand is clear, and is likely to meet with the approval of employers.

Be Punctual. The time of waiting may be ended by a request from some firm for a youth to attend a personal interview. Little advice can be given in respect of this, beyond a caution to be strictly punctual in arriving. Frank answers should be returned to such questions as are asked. The interview may result in an engagement. Salary and hours of work will be named, duties briefly indicated, and in a day or two the youth will find himself installed as office boy.

In a large office there may be several boys; in a comparatively small house one will probably be sufficient. The duties to be undertaken will accordingly vary somewhat, but many are common to all offices. The necessity for obedience must be earnestly impressed on the beginner. This does sometimes, although not always, mean that he is to be at the beck and call of all and sundry in the office. Frequently, however, he will be "told off" to one person, and orders from him must be promptly and cheerfully carried out. It should be recognised at once that no office can be effectively conducted without a certain measure of discipline; and this is as necessary for the well-being of all the staff as it is for the good name of the house, in which its youngest member should early begin to take a pride.

Copying and Dispatching Letters. The office boy whose duty it is to get letters ready for the post is often known as the post boy. He will have to carry the letters when typed or written to a principal for signature, then to copy them in the appropriate letter books, write the addresses on envelopes, and stamp and post the packets in time for the mails. Anything which is put into an envelope in addition to the letter which has been copied is termed an enclosure, and the number of enclosures is marked on the letter: thus 3E means that there are three other things (usually papers of some sort) to go with the letter into the envelope before it is sealed down, and it is the duty of the post boy to see that all enclosures are properly dealt with. It is not proposed to describe the various methods in vogue of copying handwritten and typewritten correspondence. Practice alone will make perfect, and there are very few instances where the office boy or post boy will not be able to call on someone to show him just how to perform the operation. It may also be noted that printed instructions as to copying are to be found in some letter-books. For an explanation of special methods of press-copying, and of multiplying facsimile documents, consult the section of this work on Business Management.

Indexing Letter-books. A word or two as to indexing the letter-books may not be out of place. The object of keeping several letter-books going at the same time is to facilitate reference. Take, for instance, the simplest case where the letters from the Counting House are copied in one book, and those from the Showroom in another. It is clear that the indexing has begun from the moment that a letter is copied, because by that very fact it has been indexed to a certain book, although the name does not as yet appear in the index. If, therefore, a letter to William Brown, Esq., is copied on page 240 of the Counting House book when it should have been copied on page 375 of the Showroom book, the object of keeping two books has been defeated to this extent.

The best way to remedy the blunder would be to index the letter in the Showroom book, thus: Brown, Wm. 240 C.H. Book.

But stop a moment to think of the wholly unnecessary trouble to which everyone concerned is put by a fault of this kind, and be more careful next time!

Indexing the Books. The indexing of the letter-books is carried out daily or weekly. Each letter is entered alphabetically by name, the number of the page on which the letter appears being also noted in the same line. Sometimes there may be a doubt as to the correct arrangement when a Christian name forms part of the firm-name, as John Smith & Co. Should this be Smith & Co., John, or Smith, John & Co.? Reflection will convince the enquirer that the second method is open to misconception, as it is quite possible there might be a firm actually trading under the style of Smith, John & Co., and if we were to have dealings with both these firms, and were to index letters to each of them under the caption Smith, John & Co., confusion would result.

The system of cross references in indexing should always be adopted, as affording additional convenience to those who wish to look up letters. It consists in blue pencilling at the top of each letter-copy the nearest backward and forward pages respectively on which letters to the same person or firm appear. Thus, if there were letters to Messrs. Jones & Robinson on pages 8, 16, and 24, on page 8 would be written $\frac{-}{16}$, on page 16 would be written $\frac{8}{24}$, and on page 24, $\frac{16}{-}$. The last entry can only be completed if and when a further letter to Messrs. Jones & Robinson is copied.

Letter-filing. Letters received also require to be indexed. This may be done by means of one of the many files now in use, such as Stone's, the Shannon, etc. Incoming letters are often numbered, say from 1 up to 10,000, and then they can be indexed and cross-referenced, as in the copy letter-books. Instead of being filed, correspondence is often "Pigeon-holed." In this case the letters are folded to one convenient size, with opening to the right, secured in bundles and placed in the alphabetical compartments of a wooden frame or cabinet. In order to save time in referring to letters

1905

J. Ash & Co.

25 Jan.

when pigeon-holed, they are "docketed" or endorsed outside with the year, writer's name, and date, so that the letter required is easily picked out. Care should be taken that letters brought out for reference are replaced in the proper bundle without delay.

The Post Office Guide. The post boy will acquaint himself thoroughly with postal regulations, both as regards letters and parcels. He will know the hours when mails are dispatched to town and country, the rates of postage for home and foreign letters, the particulars as to registration, late-fee letters, dispatch of telegrams, etc. He should aim at being considered an authority in the office on these matters. His text-book will be the Post Office Guide, issued quarterly, or the local handbooks published by the Postal authorities in large provincial towns. Where small parcels are frequently sent by rail, the office boy should learn how to proceed in the matter, and know the ordinary rates and charges.

The Postage Book. It is probable the post boy may be required to take charge of the stamps, perhaps also of the petty cash. Every stamp used and every item of petty cash paid must be entered immediately in the books provided for the purpose. There must be no trusting to memory. For most cash payments a receipt or voucher should be obtained. This should be read through to see that it corresponds with what has been done, and is correctly dated. It must then be filed away in the manner in use at the office. A common form of postage book is as follows:

Received.		Date.	Name.	Where Posted.	Time of Posting.	By Whom Posted.	Amount.
10	-	1905 *Sept.* 1	*J. Carrick*	*Post Office Court*	6.30	*A. K.*	1
			Adams & Co.	*do.*	*do.*	*A. K.*	1
		2	*New Tyre Co., Ltd.*	*do.*	*do.*	*A. K.*	2
			L. A. Cox, Reg.	*do.*	11.30	*T. L.*	3

The amounts received from Petty Cash and laid out in stamps are entered in the left-hand column, and postages on the right. The difference in the two totals at any time represents the value of the stamps in the stamp box. The balance should occasionally be tested by another clerk. The person actually posting the letters should initial the postage book.

The Telephone. The office boy will have to attend to the telephone occasionally, if not indeed regularly. When giving a message, he must be sure that it is clearly understood, and when receiving one he should see that it is delivered at once to the person for whom it is intended. If he is out, a carefully-written note of the message should be placed in a prominent position on his desk. In some offices a telephone message form is in vogue, the systematic use of which will minimise mistakes and consequent annoyance. A specimen is as follows:

TELEPHONE MESSAGE.

No. *64* Time *10·45* Date *Oct. 15/05*

From *J. W. Mason* To *Us*

Enquiry.	Reply.
Can he see our Mr. Gray if he calls here in half an hour?	*Yes. Mr. Gray will be in until noon.*

Received / Sent by *H. S.*

The telephone in the general office is sometimes connected with others in different departments or in principals' rooms, in which case the method of using the "switch-board" must be learned. The card of instructions issued by the Telephone Company to its subscribers should also be studied.

Be Cheerful. We have by no means exhausted the list of duties, sometimes menial, often petty and humdrum, required of probationers in commercial life. Since, however, each house of business has its own conception of the uses of the office-boy, it must suffice to mention in a general way a few of the matters which may demand his attention, and to point

out that *the manner in which he discharges irksome tasks* is often taken into account by superiors when the time comes for the salary schedule to be revised at the end of the year or half-year, as the case may be. If, therefore, you are required to clean out an ink-well or to dust out a cupboard, do not be satisfied with half measures, but, because "Cleanliness is next to godliness," see that the work is done so that no one can find fault with it. If you have to make a copy of a document in your own handwriting, let it be an exact copy, not with a comma misplaced or a word spelled wrongly. If sent on errands be sure that you deliver your messages correctly. If, as sometimes happens, you should act as an "enquiry" clerk, always be scrupulously polite and obliging to callers, who are quick to judge the tone of the establishment from the behaviour of the enquiry clerk.

A Safe Rule. Cheerfulness and painstaking in the fulfilment of the "daily round and common task" are indispensable factors of worldly success. Learn to take pride in all honest work. Banish from your mind the distinction between important and unimportant matters, because, as a matter of fact, there are no such things as trifles, or if there be, you are not wise enough to be able to discern them. The safe rule is to put first-class work into everything you do, and it may help you to know that the world's great men have always paid great attention to detail. Genius has been defined as the capacity for taking infinite pains. The great captains of industry, who marshal the forces of production and distribution and control the vast movements of world-wide commerce, are men who combine executive ability and organising power with a capacity for grasping the smallest detail of business administration.

It should be unnecessary to state that betting, drinking, bad language, smoking and loafing ought to find no place in the category of a junior clerk's accomplishments. If, unhappily, he become addicted to evil habits, it does not need prophetic inspiration to enable an observer to predict a sad end to the usefulness of such a clerk. He will ultimately, unless a worse fate overtake him in the meantime, drift into the class of unemployed whose mournful cry is, "Too old at forty!"

Be Diligent. Solomon said, "Seest thou a man diligent in his business? he shall stand before kings." How true this is may be proved by citing one example, that of the great banking house of Rothschild, whose influence for peace or war has been felt in all the Courts of Europe because the attention to business of the founders and their successors has made the Rothschilds the controllers of millions of pounds sterling, and without money, which is the "sinews of war," war cannot be carried on.

Diligence, then, must be our watchword as we pass up from the ranks of office boys to the grade of junior clerk.

The diligent office-boy will discover one day that his status—that is to say, the estimation in which he is held by his fellow clerks and others—has been gradually improving. Having settled down to the office routine and acquired a certain degree of business method, it is more than likely that he will be able to spare an hour or so daily from his own duties to help someone else—the ledger clerk, it may be, who, for the sake of the assistance rendered, will readily give him an insight into his own more complicated work. Presently, when the ledger clerk's work increases beyond the point where he can cope with it single-handed, he will ask for a permanent helper. What more natural than that the youth who has assisted him from time to time should now be appointed to the post of assistant ledger-clerk?

The Junior Clerk. But, in whatever way promotion comes, the first step upwards cannot be taken until a proper aptitude for office life has been displayed. There is a case within our recollection of a young man who had performed the duties of office-boy for some years, only to discover at last that he was not suited to clerical work, and would have to begin his career again in some other sphere of activity. Surely a sad waste of time!

The change from office boy to junior clerk is likely to be a gradual one, but, as we have indicated, it will often show itself by opportunities for more advanced work. To recognise opportunities and to be able to seize them are the signs of business capacity, but there are some men who are said to create opportunities. These belong to the highest rank in commerce, and they are one and all students of books and men. Mr. Andrew Carnegie is a conspicuous example of this class, and it is partly because he made such good use of the free library in his youth that he has the means to endow so many free libraries to-day.

Book-Keeping. Clearly, then, we cannot afford to rest content with the amount of book knowledge we already possess. Two, three, or four nights a week might be devoted without injury to health to the study of commercial arithmetic, modern languages, Latin, or any other branch of knowledge in which the clerk may be specially interested, or which he thinks might be useful to him in his career. A knowledge of bookkeeping is considered indispensable to the vast majority of clerks, and it is hoped that our study of it may be profitable. It is but fair to the student, however, to explain that our treatment of the subject will not be conventional. We do not think it necessary to begin by defining the uses of certain books and forms which are fast becoming obsolete. These, undoubtedly, have practical as well as historic value, but it cannot be too earnestly impressed upon the mind of the student that the principles of double-entry book-keeping are always the same, although there is great diversity in practice. It follows, therefore, that if the student can get a clear notion of but one of the many up-to-date systems of double-entry book-keeping, it will pay him to do so rather than to spend time in learning how to keep books by an old-fashioned method, and how to adapt it to modern requirements.

Group 26

PHYSIOLOGY

2

SYSTEMS AND ORGANS OF THE BODY

**How the Human Frame is Built. Heart and Brain.
The Six Systems of the Body and their Vital Unity.**

By Dr. A. T. SCHOFIELD

HAVING taken a broad and comprehensive survey of the plan of the human body, we may now look at the general construction of the body and its organs, and the materials of which it is built, reserving for later attention the minute and exact formation of these materials and their chemical composition. In addition, we may consider that change—or, as it is called, Metabolism—in which life consists, with the manufacture of body, heat, and the general gain and loss of the body. By the time these things are understood we shall be in a position to follow intelligently the physiological and vital actions of the various systems of the body.

How the Body is Built. In a building such as the body it is well to begin with the *unit* the building unit. In a house this is a brick or a stone; in all living structures, animal and vegetable, it is a *cell*. Just as all bricks are very much alike, whether used to build a palace or a pigsty, so are all cells, whether they are built up into mice or men, or even into fruits or flowers.

All living structures, therefore, whether animal or vegetable, are built up of cells (which we shall consider in due course), and these cells are grouped together for different purposes to form different tissues. The *tissues* are the different materials of which the body is made; just as clothing may be made of silk, cotton, or woollen tissues or materials. There are eight principal tissues in the body: *bone, gristle, muscle, nerve, skin, fat, fibre,* and *connecting* tissue.

1. The *Osseous*, or bone tissue, is the framework of the body. This material is found, of course, in every part of the body and forms the skeleton.

2. The *Cartilaginous*, or gristle, forms the joints of the body. This tissue covers the ends of the bones to form the joints; it unites the ribs with the breastbone; it forms the rings of the windpipe and the lid of the larynx at the back of the tongue; the lower part of the nose, the upper eyelid, and the ear.

3. The *Muscular*, or muscle, forms the machinery of the body. This tissue covers all the bones with flesh, which is muscle, and is the chief part of a number of machines by which every movement is performed. It is also an important tissue in the wall of the abdomen and the floor of the chest.

4. The *Nervous*, or nerve tissue, is the moving power of the body. It is the chief constituent of the brain and the spinal cord, inside the backbone or spine. It also forms the nerves, which run like white threads from the brain to all the muscles, and gives them power to move.

2. THE BRAIN AND SPINAL CORD

5. The *Epithelial*, or skin, forms the outer covering of the body. This tissue is the skin that covers the body outside, and lines it as mucous membrane inside, and also forms the teeth and nails.

6. The *Adipose*, or fat, forms the under covering of the body. This tissue is the inner protective sheathing and padding of the body, beneath the skin, and round the internal organs. It consists of drops of oil, enclosed in separate cells.

7. The *Fibrous*, or fibre or sinew, is the tissue that forms the cords and bands of the body. This tissue makes the strong tendons that fasten the muscles to the bones, and forms the covering or sheath of the bone itself, and the various organs.

8. The *Connective*, or cementing tissue, joins all the parts and cells of the body together. This substance is found everywhere, all over the body, and is like the mortar in a house, fastening all the bricks together. It is a sort of network of cells and long fibres.

Special Systems. These eight tissues are combined together into various groups of *organs* or SYSTEMS for special purposes. These groups are *six* in number, and include: the *circulatory, respiratory, digestive, excretory* or *secretory, locomotor*, and *nervous*. There is also the *reproductive*, which is considered in the section on BIOLOGY. We may divide these six into three groups of two each. There are two in the chest:

1. The *Circulatory* system is that by which the blood or liquid food is distributed all over the body to all the tiny cells. This system includes the heart or force-pump, and the arteries, capillaries, and veins, or the three sorts of pipes through which the blood travels.

2. The *Respiratory* system is that by which we breathe, and by which the body is fed with oxygen, which gives the blood its bright red

colour. This system includes the nostrils and mouth, the windpipe and the lungs.

Then there are two in the abdomen, or stomach:

3. The *Digestive* system, by which all the food is made into liquid and changed so as to nourish the body and pass into the blood. This system includes the mouth, gullet, stomach, liver, pancreas, intestines, and other organs.

4. The *Secretory*, or excretory, system (for they are best grouped as one) manufactures the various fluids of the body, such as bile, urine, sweat, saliva, gastric juice, etc. It consists of various glands or secretory organs in different parts of the body, such as those in the skin, the kidneys, the lymphatic glands, the spleen, etc. It also gets rid of the refuse of the body.

Lastly, there are two in the head and limbs:

5. The *Locomotor* system, by which all movement is effected. This includes the bones, joints, and muscles.

6. The *Nervous* system, by which all the body is controlled, directed, and regulated. This system includes the brain, spinal cord, and the special senses, such as the ear, the eye, and all the nerves.

We have considered already the division of the body into *two tubes*, the *posterior*, which, with the limbs, is the seat of the engine, or the *animal life*; and the *anterior*, that of the boiler, or *vegetable life* of the man.

Man's Brain. We shall first consider the head, including the face, and the spine, or the engine (the posterior tube). Then we may look at the *chest*, or upper part of the boiler (the anterior tube), where the steam is made, and, lastly, at the *abdomen*, or lower part of the anterior tube, where the fuel is burnt.

The *head* and *spine* contain the principal nervous systems of the body and four organs of special sense—*sight, hearing, smelling*, and *tasting*.

The *brain*, which fills the head, consists of two parts: the *Cerebrum*, or greater brain [9], and the *Cerebellum*, or lesser brain, placed behind and below the larger one. The greater one is about the size of a melon, and the lesser one of a small orange. From this brain nerves run to every muscle of the body, enabling them to move the limbs and body as the mind directs; and another set of nerves run from every part of the body and skin to the brain, enabling the mind to know and feel all that goes on. The brain is connected with the spinal cord by a flat band of brain matter, that lies on the inside of the occipital bone, called the *Medulla Oblongata*, or the Oblong Marrow. The *spinal cord* [9] runs through a large hole in the occipital bone and right down the open tube formed by the spinal vertebræ, to the bottom of the back-bone, and all along its course nerves leave it and enter it, as in the brain.

The organ of sight consists of the two eyes, which receive every image that we see, and transmit it to the brain. The organ of hearing consists of the two ears, by which we receive all the waves of sound that we hear, and transmit them to the brain. The organ of smell is in the upper part of the nose; the organ of taste at the hinder part of the tongue.

The organ of the voice is contained in the larynx in the neck, which joins the head to the body. Just under the chin in front of the neck you can feel what is called the *Adam's Apple*, which is the front of the larynx, or voice-box, by which the air coming out of the lungs is formed into sounds. The sounds are formed into words by the mouth, tongue, and teeth.

The Chest. The *Chest*, or *Thorax* [10], forms the upper part of what may be termed the human *boiler*. In it the blood, which is like the *steam* of the body, is purified and circulated. The *thorax* is closed above and below: above, by the neck, through which the windpipe enters it in front, conveying air to the lungs; and by the *gullet* behind, conveying food to the stomach. Below, the floor, dividing it from the abdomen beneath, is formed by a very large muscle stretching right across the body, called the *Diaphragm*, or partition wall, also called the *Midriff*. The thorax is walled in at the sides by the ribs, and behind by the backbone, in which is the other tube that contains the spinal cord. The thorax contains the two organs of *respiration* and *circulation*.

The *lungs* are the organs of respiration. They are like two sponges filling the right and left halves of the chest. Wherever you can feel a rib there is part of the lung underneath. Each of these lungs is contained in a bag, like a skin, that separates it from the ribs, and is called the *pleura* (from *pleuron* = a *rib*), but the lung is not *inside* the bag.

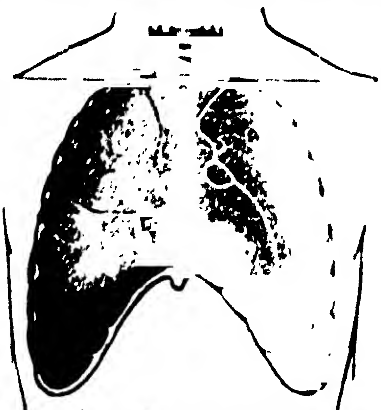
You will understand how this is possible if you take a paper bag and a sponge, and, instead of putting the sponge inside the bag, place it against the outside, folding the empty bag round it. The sponge will then be wrapped up in the bag, yet *outside* it, covered by *two* layers of paper.

The *outer* layer of the pleura is fixed to the side of the chest, the *inner* layer to the lung, and the two layers move on each other like a joint when we breathe.

The lungs are full of small air cells with minute tubes leading from them. These gradually increase in size as they join together, till at last they unite in one large tube, or bronchus, for each lung. These two bronchi join together, and form the *windpipe*, or *trachea*, which conveys the air through the larynx into the mouth. The windpipe is kept stretched widely open by a series of elastic rings of gristle. Behind the windpipe is the gullet, leading to the stomach. These rings in the trachea, it is interesting to note, are incomplete behind, where the trachea lies against the gullet, or œsophagus. They thus form springs rather than rings. The reason for this is that the walls of the gullet, being quite soft, if the cartilage rings rested against them, would form a series of ledges on which food would inevitably lodge, and thus interfere with deglutition, or swallowing. Here we get one of

those minute points on which the physical comfort of life depends. We take air into the lungs to pass thence into the blood, and thus be carried to all the cells of the body to enable them to live and breathe.

The Heart. The *heart* is at the lower part of the chest, between the two lungs. It is a *fleshy* or muscular organ, about the size of the fist—flat above, and pointed below like a sugar-loaf. It lies in a slanting direction behind the breastbone—the broad part, or the *base*, of the heart being upwards and partly to the *right* of the breast-bone; the point, or apex of the heart, being downwards and to the *left*, where it can often be seen beating against the chest-wall. The heart is hollow, and acts like a pump, forcing the blood all over the body through the great vessel that leaves the heart at the upper part. The heart, like the lungs, is enclosed in a double layer of folded bag, called the *pericardium*, because it is round the heart.



10. THORAX AND CONTENTS

The *gullet* runs right down the back of the thorax, and passes out through the diaphragm, which forms the floor, into the abdomen.

The *abdomen* [11] forms the lower half of the trunk, and is often called the *stomach*. Many parts of the body are called by more than one name, which frequently causes confusion. Thus the trunk, which is made up of the *thorax* and *abdomen*, is sometimes called the body, of which it really only forms a part. In the same way the word stomach is often applied to the whole abdomen, of which it only forms a very small portion. The *trunk*, as we have seen, is composed of the thorax and abdomen—which together form the human boiler, in which, by means of food fuel beneath and air above, steam is generated to work the engine, which in the body consists of the brain and spinal cord.

The abdomen, which forms the lower part of the body, is full of organs belonging to the *digestive system* and *secretory system*, by which the fuel or food is rendered fit for use in the blood and the body.

11. THE ABDOMEN

The *walls* of the abdomen are not protected by ribs like the thorax, but are all formed of flesh or muscle. The principal organs they contain are the *stomach*, the *liver*, the *pancreas* or *sweetbread*, the *spleen* or *milt*, the *kidneys*, the *intestines*, and the *bladder*. We shall reach them all in due course.

Man's Framework. All these organs and systems are held together and formed into one body by means of a framework, partly fixed and partly movable, partly rigid and partly flexible, partly hard and partly soft.

The skeleton part of the framework is made of bone; flexibility is given to certain parts by means of joints, which are simply smoothed and rounded ends of bone covered with gristle to avoid friction, and joined together by fibre and ligament for strength. This forms the rigid and hard parts of the framework. The flexible and soft part, which everywhere covers organs and muscles, is composed of a layer of fat to preserve the warmth, as fat is a non-conductor, and an outer covering of skin.

This framework is exquisitely adapted to give strong protection to the vital parts so that they cannot readily be injured; and the whole of the organs are so arranged and stowed away that, as we saw in the last chapter, a perfect human body is a beautiful object, full of symmetry and graceful curves and lines.

The Vital Spark. But more is needed than this for a living body; there must be a vital unity. So far, all we have is a picture of six systems, constructed in different proportions of eight tissues, and held together in bodily shape by an elaborate framework, and containing a large number of complicated organs. But all this is complexity, not unity. Where is the centre, where the directing power that starts the engine, and moves all the machinery in perfect rhythm, all unconsciously to its owner, who has, as we all know, but scant power to interfere with any great vital processes, and none at all to direct them?

This is the very point on which so many of our text-books are silent, and therefore fail to give us, in all their descriptions, a true conception of a human being, and are wearisome and dry, because the living soul, the vital spark, is absent.

The Mind and the Body. Any student of a modern medical text-book on physiology can well understand how the mass of dead material facts, which fill its pages, would be "vitalised" if their dependence on the central directing force were laid bare, and the unity that underlies diversity in man demonstrated. "The mind so acts on the body," a well-known authority has put it, "that .... the body performs only a

limited range of its functions without intelligent (unconscious) direction."

Some governing centre must regulate, control, counteract, guide, and arrange and unify the actions of the human organism with regard to the continual succession of differing events, foods, surroundings, and conditions which are ever affecting it in endless succession, and in constant variety, enabling it, amid this bewildering multiplicity of changing influences, to hold on its steady course of growth, health, nutrition, and self-maintenance with the most marvellous constancy.

It is quite clear that this governing centre is mental in nature and unconscious in character, and whether we call it "Nature" or the "Unconscious mind" matters little, so long as we recognise that it is this mind that not only vitalises but unifies this wondrous body, and blends all into one living personality.

Soul and Spirit. But a man, as we have seen already, is even more than an animated and unified body. He has not only his personality and his bodily vitality to maintain, but also his relation with this world and the next, and to this end he is endowed with a soul and spirit, placed in connection with and under the control of a conscious mind. By means of his *animal* life he maintains his relation with his environment and becomes a part of all around himself.

By means of his *spirit* life he has intercourse and relations with what is above him, with the unseen world, with abstractions, with the ideal, with the Infinite—with God.

This tripartite being - governed, as regards the body, by an Unconscious Mind, and, as regards soul and spirit by a Conscious Mind—this, and nothing less than this, is a *man*.

CONSTRUCTION OF THE BODY

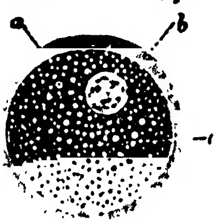
The Cell. In considering the minute construction of the body, we must first of all examine the *cell*. Let us first grasp the broad fact that not only are we alive, but that our bodies are throbbing and pulsating with millions of independent and active cell lives, over which we reign as autocrats. We have more living subjects in the body than the Czar of Russia has in his vast empire. That is the statement of a literal fact. These subjects are, fortunately for us, not directly under the sway of our capricious wills and passions, but are calmly and wisely governed for our good by the unconscious mind.

Let us then clearly grasp the fact that the body is *alive* everywhere but on the surface. The *outside* of the skin is dead, as we shall see later, but every other part is alive. Whenever we enter the body (figuratively) we are surrounded with the most varied and busy existences, all pursuing their different tasks, callings, and occupations for the common good, and thus forming an ideal community, under the wise and beneficent sway of the all-powerful autocrat—the unconscious mind. This is no fancy picture, but sober fact; and every fresh detail of physiology that comes to light confirms it. The *cell* [12] forms the basis not only of Physiology, but of Biology; for it is the Embryological (the construction of life), Morphological (the form of life), as well as Physiological (the process of life) unit.

This fact was first established by Schwann, of Germany, whence most of our facts come. This cell consists of two essential parts, the *body*, and a darker part inside it called a *nucleus*, and sometimes of cell wall, which makes a third. Every part, not only of animal, but of vegetable organisms, is built up of cells, which consist, therefore, essentially of a *nucleated mass of protoplasm*, varying in size in the human body from $\frac{1}{3000}$ inch in the blood to $\frac{1}{300}$ inch in the brain

Protoplasm. Protoplasm is a living, transparent, viscid, insoluble, unstable substance of a proteid nature, containing 70 per cent. of water. It coagulates with heat at 130°, and dies when the body is raised to this temperature.

A cell manifests its vital properties in that it is *born*, *grows*, *multiplies*, *shrivels*, and at last *dies*.



12 A CELL, showing its structure
a, Zona pellucida; b, germinal vesicle; c, protoplasm

During its brief life it assimilates food, *breathes*, *works* and *rests*. It is capable of spontaneous motion, and frequently of locomotion. It can secrete and excrete substances, and, in short, it presents nearly all the physical phenomena of the life of a human being.

BIRTH. Cells are produced only from cells by *gemmation* or *fission*. The former, a budding off of a small part of the cell, is rare in man. *Fission* is a dividing of the whole cell, including invariably a part of the nucleus. The process is very quick, and may take place in a few minutes.

GROWTH. The cell rapidly increases in size to a certain definite point, which it maintains during its adult life, like a human being.

DECAY. As it gets older it is frequently removed further from its source of life (the blood-stream), making way for more vigorous life (as in epidermal structures), and gets wrinkled and smaller and flatter, like an old person.

DEATH. After a life of from a few hours to a few days, it finally dies and dries, becoming in the skin a mere horny scale on the surface of the body. Internally its death is frequently brought about by its breaking up or dissolution, as in the secreting glands, where the cell itself dissolves away to form the secretion—such as saliva.

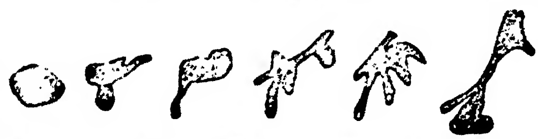
ASSIMILATION. It can take in food from the blood by absorption; or, as in the *amœba* (or freely moving cells), by flowing round a substance of a solid nature, and thus enclosing and subsequently digesting it.

RESPIRATION. The cell inspires oxygen (O) and expires carbonic acid gas (CO_2) which is

probably the result, as it is in man, of its *metabolism*.

Work. This is of the most varied kind, and embraces the formation of every tissue and every product — solid, fluid, or gaseous — of the body.

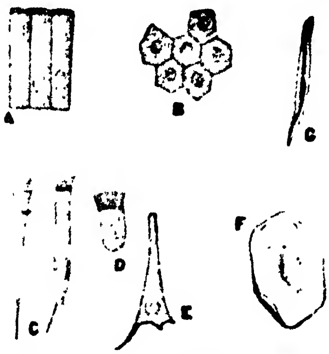
Rest. This work may be intermitted. It is found that in the dark the colour-cells cease to secrete pigment. Muscle-cells and all others have intervals of rest.



13. A WHITE BLOOD CORPUSCLE; VARIOUS PHASES OF ITS MOVEMENT IN THE BODY

Motion. This interesting quality of cell-life has only been carefully studied of late years. Most cells have a limiting membrane or *cell-wall*, consisting merely of the hardened exterior of protoplasm. This, however, is in many cases capable of assuming the most diverse shapes, known as *amœboid movements*. If a colourless corpuscle is examined on a warm microscopic slide in a saline fluid, it is seen constantly to change its shape by pushing out or retracting some part of its mass.

In vegetable cells, spaces or *vacuoles* occur within the mass, and are continually changing their shape, so as to cause the granules in the protoplasm to flow in streams. Another beautiful form of motion is found in ciliated movements.



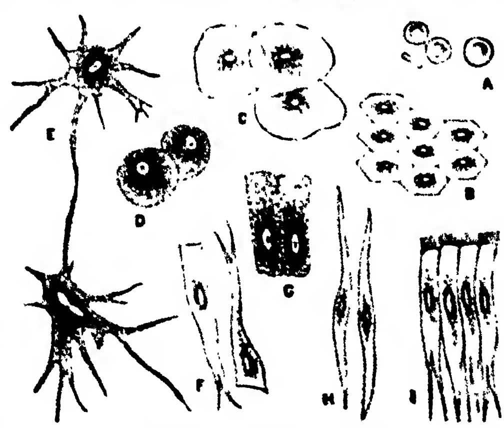
14 KINDS OF EPITHELIAL CELLS

A, Columnar cells of intestine; B, polyhedral cells of the conjunctiva; C, ciliated conical cells of the trachea; D, ciliated cells of frog's mouth; E, inverted conical cell of trachea; F, squamous cell of cavity of mouth, seen from broad surface; G, squamous cell, seen edgeways

The *ciliated epithelium*—the lining membrane of the air-passages and other parts—consists of cells having on their surfaces rows of from ten to thirty small hairs, which are incessantly moved with a distinct *lashing* motion in one definite direction, several times every second. Some cells move by the lashing of a long filament at the end of the small cell, by which they can progress for some inches.

Locomotion. Cells may move actively or passively. In the blood the cells are borne along by the current, but colourless corpuscles seem able to make their way actively and at will—if we can speak of will in such bodies—about any part of the body. Their movements appear to be guided by some sort of instinct, and are by no means haphazard [13]. Careful research by Metschnikoff at the Pasteur Laboratory has shown that colourless corpuscles flock to any part of the body, where any inflammatory or infectious process is going on (from the leg to the cornea, for example), and there do their best to rid the body of any intruding bacteria by swallowing them. *Amœboid* cells of this type have been seen to work themselves up through the deeper tissues surrounding the bowel, pushing aside layers of cells in their course, and emerge into the intestine, and then seize on bacilli, and after swallowing them, make their way back again.

Animal Cells, all originally of a more or less rounded shape, attain the most varied forms, in accordance with the tissues to which they belong [14]. They may become hexagonal, as in many internal membranes; polyhedral, discoid, as in the blood; prickly, as in the epidermis; scale-like, as on the surface of the skin; columnar (like bricks on end), as in the deepest layers of the skin; cubical, as in many organs; wedge-shaped, as in the salivary glands; crescent-shaped, branched, stellate, as in nerve tissues; fish-shaped, forked at one end, as in the ureters; canoe-shaped, as in muscle; or ciliated, as already described. Again, they may become fibres, as in connective tissues; or tubes, as in capillaries [15].



15. VARIOUS BODY CELLS

A, Blood cells; B, pavement cells; C, epidermis cells; D, lymph cells; E, nerve cells; F, ureter cells; G, columnar cells; H, smooth muscle cells; I, ciliated cells.

The cells are mostly connected together by *intercellular substance*, originally produced by their own bodies. This consists of a material like protoplasm, only without vital properties, or it may consist of deposits of lime salts, or of fine fibrillar material. The cells may, on the other hand, be in direct contact with one another, and united by thin walls or processes. From these two materials, of which the cells are the bricks, and the intercellular substance is the mortar, the whole of the body is built up.

To be continued

Group 17
IDEAS
2

THE INCALCULABLE POWER OF IDEAS

Ideas which have Changed the Face of the World. Creators of New Industries. Pioneers of Revolution. The Golden Key of Fame.

By ERNEST A. BRYANT

WHEN the British Association met in South Africa in the summer of 1905, two striking illustrations of the power of an idea were afforded to even the most casual observer.

The first was well expressed in the inaugural speech of the President, Professor G. H. Darwin. He said: "Bartholomew Diaz, the discoverer of the Cape of Storms, spent sixteen months on his voyage, and the little flotilla of Vasco da Gama, sailing from Lisbon on July 8, 1479, only reached the Cape in the middle of November. These bold men, sailing in their puny fishing smacks to unknown lands, met the perils of the sea and the attacks of savages with equal courage. How great was the danger of such a voyage may be gathered from the fact that less than half the men who sailed with da Gama lived to return to Lisbon. Four hundred and eight years have passed since that voyage, and a ship of 13,000 tons has just brought us here in safety and luxury in but little more than a fortnight."

Conquest of Time and Space. The comparison would have been still more striking had Professor Darwin mentioned then, as he did mention at a later meeting of the same august body, that his own great-grandfather, Dr. Erasmus Darwin—whose speculations in the direction of natural selection had in some measure anticipated his illustrious grandson's investigations—had predicted, a century and a half earlier, the means by which the British Association was enabled so rapidly to make the passage. But when Erasmus Darwin spoke of engines driven by steam, he spoke to men in what to them was a parable, which they did not understand any better than men of all preceding time had understood. The germ of the idea was in many men's minds, but Watt and Stephenson were yet unborn, and there was no one to bring it to birth.

The second thought which must have struck the observer was that though the British Association was meeting six thousand miles away from London, yet we were all able at breakfast on the following morning to read the report of their proceedings, their excursions and discussions.

Steam and the Telegraph. In those two instances of facilitated and safe travel, and the rapid transmission of news from one hemisphere to another, we have typical examples of the power of an idea. Steam has existed ever since the sun warmed the waters of the earth; yet not until Queen Victoria had been a year upon the throne did it occur to man seriously to apply it to navigation by employing it to drive a vessel across the ocean. All the possibilities of the telegraph were of coeval birth with civilisation, but the practical application of the idea antedated the steamboat by only a year. And then its projectors dared not dream how vast and significant was their creation. They little thought that, fourteen years later, a cable weighing 2,500 tons would be laid across the Atlantic. Only its detractors were certain as to anything. They "knew" that the project must fail; they "knew" it for another eight years. And then the Atlantic was effectually bridged by electricity, and the thousands of miles separating the old world from the new rendered as inconsiderable as the distance between one parish and another.

The value of the idea which gave us wireless telegraphy we are even now unable to estimate. So illimitable is the horizon opened by this new phase that not the most speculative can fix the limit of its scope. It may change the conditions of our lives in many ways of which we do not dream. Our relations with distant friends, to think of one example only, may be entirely altered; the friend across the world may become an almost next-door neighbour. One thing is certain—in the not distant future we shall see the boast of Ariel left a relic of a dark age. The cables have already done for us what he promised; they do put a girdle round the earth in forty minutes. What the new principle will effect will be to send the human voice the same journey in one-sixtieth of the time.

The First Lucifer Match. The significance of an idea can never be realised at the moment of its birth. The alchemists were the first to discover the readiness with which sulphur can be ignited, but they left their discovery at that. Meanwhile men, civilised and savage, sought their fire as men had sought it from prehistoric days. The savage rubbed wood; the civilised plied flint and tinder as they had been plied from the dawn of the iron age. Then came a simple Stockton chemist, to whom occurred the idea of making the first lucifer match from pieces of wood dipped in chlorate of potash and sulphur. At one bound the ages were left behind, a boundary between civilisation and savagery established. Even more striking was the advance made when the light of coal-gas first beamed forth upon the waters of the Thames from the pioneer lamps upon Westminster Bridge. The oil lamp of the savage was rough and crude and filthy; that of the philosopher and warrior of cultured Greece and Rome beautiful and ornate; but both were the same in principle. British history in Parliament was all made by candle-light, or by the feeble flame of the bowl of fat and wick of fibre. Then a man's idea literally illumined the dark

places of the cities of the world; and the electric light, wonderful as it is, was the less wonderful when it came, because of the manifold merits of its predecessor and rival.

Intellectual Capital of the Race. These are facts which enable us, by contrasting the present with the past, to appreciate the power of ideas. The ships with which Nelson crushed the naval might of Napoleon were but developments of the war galleons of the primeval Norsemen, and depended upon the principles on which the savage relies as he cuts his way through the waters of the silent rivers of America or Africa. A single first-class ironclad of to-day would sink the combined fleets of Nelson and Napoleon. And men's brains are daily exercised to bring about new devices which shall render the present fleets of the world as useless as the old warships of unarmoured oak.

When a thinker gives an idea to the world he increases the intellectual capital of the race. He cannot say in what proportion profit will be reaped; he cannot always predict in what direction results will tend; he cannot, from his close-range view, see very clearly whether his discovery be a pearl of price or merely a day-dream, unworthy of permanent record. He must put it to the test. Alfred Russel Wallace, dreaming his feverish dreams in the Moluccas, was too modest a man to let himself believe that he had solved a gigantic problem when one afternoon there flashed in an instant upon his mind the idea of Evolution, the survival of the fittest, and the variation of species. That evening he drafted his theory; on the two subsequent nights he elaborated it. Then he posted off his notes to Darwin. Neither had guessed that the other was working on the subject; neither for a moment suspected that he was about to create a revolution in thought which was to rouse the whole civilised world to the highest pitch of excitement. But Darwin, as we all know, was already engaged upon the work of his life, fearing meanwhile, as he replied to Wallace at the time, that "my work will not fix or settle anything." He did fix and settle a great deal, as it was his privilege in after years to feel assured. But there are countless secrets yet to be rapped out of the stony bosom of Mother Earth. Darwin and Wallace and their school gave us the hammer wherewith to do the tapping.

How a Pestilence was Destroyed. As well by example as by precept, leaders of thought and action teach us how imperative it is alertly to act upon inspiration. Louis Pasteur, whose mighty brain was a magazine of ideas, impressed upon his students that "in the field of observation, chance favours only those who are prepared." His own record is a signal exemplification of the power of an idea. What to the ordinary, unimaginative analytical chemist would be the significance of two vats of beer containing, the one sour beer, the other good? To Pasteur it meant the opportunity to revolutionise chemical and biological science. It meant to the world that a great and devastating pestilence was to be struck dead. The microscope revealed the fact that the globules of the sound beer were nearly spherical, while those of the sour beer were practically globular. Experiments showed that wine and beer and milk are turned sour by the growth of atmospheric organisms, and that when these are excluded the liquids remain sound. If wine and beer and milk can be kept sweet when protected from putrefactive germs, why not other forms? Lord Lister, as he told us in a memorable address, seized upon Pasteur's discovery, and the antiseptic treatment for wounds was born.

A Revolution in Surgery. Until then, anæsthetics, that Godsend to suffering humanity, had proved rather a curse than a blessing. In the days when operations had to be borne by conscious patients, the man with the readiest knife and strongest nerve was the most successful craftsman. A serious operation must be raced through, or not attempted. With greater leisure afforded for more extensive and delicate operations, the scope of the surgeons was enormously enlarged. But pestilence stalked in the wake of the new discovery. Gangrene became epidemic in the hospital wards of the world; in places it was attended by a mortality rate of over sixty per cent. after operations. With Pasteur's discovery developed by the master hand of Lord Lister, surgery was revolutionised, and no operation impossible.

No person imagines that the birth of even so epoch-marking an idea as this constitutes a royal road to perfection of knowledge. Pasteur's and Lister's investigations read like a fairy tale. Lister's in particular thrills with human interest, as we see the great mind of the thinker groping from the dark into the light; see him win his first triumph over putrefaction of the wounds by the use of carbolic which caked upon the incision, and by the use of a spray which time proves unnecessary; then see him finally attain perfect mastery of the subject. With the antiseptic treatment added to anæsthetics no wound need now be declared hopeless, no organ of the human system too remote or delicate for effective treatment.

The Birth of an Industry. Into the gravest research and study humour will creep. We laugh at the bizarre and fantastic ornaments of savages, yet a fashion of the early part of the Victorian era was found by the scientific mind of Dr. Buckland to depend upon a misconception more ludicrous than any embraced by traveller's tale or creation of the humorist. Beautiful women, Society leaders, were wearing as charms, as earrings, bracelets and what not, highly polished substances which were understood to be rare British minerals. Certain markings and other evidences gave the brilliant Dean of Westminster a clue, and led him to an analysis of the curious adornments. The result was as he had suspected. The charms and earrings and so forth, set in gold and decorated with gems, were simply the fossilised excreta of extinct monsters by which our island was once inhabited. The discovery would

have been startling and interesting to the archæologist but nothing more had it remained there.

To the ordinary mind there does not appear any clearly traceable connection between the earring of a Society belle and a vast agricultural industry. But the second grew out of the first. Buckland recognised that in these age-old deposits, of which vast quantities were available in certain valleys and river-beds, were properties of value to agriculture. Liebig, the great German chemist, happened to be in England at the time, and the Dean took him to inspect the deposits. He saw at once that they must contain abundance of phosphate of lime. He took back some to Germany, and there made a careful analysis which bore out his theory. And from that discovery originated the great industry of superphosphates which has wrought such enormously important results for agriculture.

Future of Our Food Supply. We pay a princely salary to the man who can cook better than his fellows, who can invent new dishes from conventional material; and we make the *chef* as much a hero as if he seriously benefited humanity. For the man who does not affect the habits of the *gourmet* there is quite another hero—the Berthelot, who, from experiments in a common garden and his laboratory, devises schemes for feeding the multitude. It may be a scientific Utopia impossible for realisation, but he has pointed to a day when his schemes will enable us to convert our farms into parks and gardens and to look to the laboratory for our food supply. Every man will carry in his waistcoat pocket his tabloid supply of food, each pellet containing all the properties essential to the maintenance of life.

Such is the Berthelot dream—the dream of the man around whose work synthetic chemistry has grown to proportions undreamed a generation ago. It may be only a dream, but it is not idly to be dismissed without examination. In a rather fierce generalisation, Dr. Russel Wallace has declared that whenever the scientific men of any age disbelieve other men's careful observations without inquiry, the scientific men are always wrong. It is well to remember this warning, without unreservedly accepting it, when doubt is cast upon the promises of a Berthelot. That man should make a meal of a pellet seems hardly less probable than that he should shiver a mountain by the aid simply of liquid air, or extract from coal-tar the most exquisite dyes and scents, a substitute for sugar, a substitute for quinine, and an increasing number of amazing products. Every theory which Pasteur enunciated was denounced by some of his most illustrious contemporaries, yet in each he was right. He who had never seen a silkworm was the man destined to cure the ravages which were ruining the silk industry. He was the man whom the world was destined to bless for providing cures for, and preventives of, hydrophobia, and diseases which were slowly but surely exterminating domestic poultry; for finding the antidote for anthrax, a malady by which the whole world, animal and human, has from time to time been scourged.

Fighting Plague by Science. The field for great enterprises is still largely virgin soil. Men like Sir Norman Lockyer look to sunspots wherein to read the secret of famine and pestilence in India. Others, like Sir Clements Markham, keep their eyes upon the earth, and there win relief and benefit for the million. The story of this great man's introduction of quinine into India is the story of a noble idea daringly, unfalteringly carried through. He had to procure the tree from Peru, and the dangers and difficulties attending his task were innumerable. But he succeeded, despite all perils, and has been allotted his place in history as having performed a service of the highest value to humanity. What it means may be estimated from the fact that, unless checked by quinine, malarial fever kills more people every year in Southern India than the worst of cholera epidemics. Now, quinine is the one sovereign specific against this deadly fever. In the same category with Markham come men like Sir Joseph Fayrer, whose researches were undertaken outside his ordinary sphere as a surgeon, with a view to combating snake bites. Pioneers, each in his own path, these men translate into acts ideas for saving our great Dependency from plague, pestilence, and the poison of the serpent.

In spite of all that has been achieved, however, there remains much to be done in our tropical colonies. In India alone five million people died in 1900 from malarial fever; and there have long been more places than Sierra Leone meriting the description of "white man's grave." It remained for a soldier-scientist in Major Ronald Ross to elucidate the mystery of malaria and yellow fever; to show, after years of dispiriting effort, that the malaria germ enters the poison gland of the mosquito and is transmitted thence to the blood of the human being. The remedy is, so far, to do away with the swamps and marshes in which the mosquitos breed. Dean Buckland created a sensation by preaching in Westminster Abbey from the text, "Wash you, make you clean," at a time when cholera raged in England. Major Ross preaches cleanliness, sanitation, drainage. The remedy is primitive in its simplicity; but the idea which led to its discovery has given its possessor immortality.

Radium. When Sir Humphry Davy spoke of "radiating matter," he used a phrase which had no meaning for his generation. A century was to elapse before the idea developed fully in the minds of the gifted M. and Mme. Curé, who were to discover radium to the world. And then, at a bound, scientists were transported to a world whose border-lines had so long eluded them. Infinitesimal as are the quantities in which radium has so far been found, sufficient has come to hand to demonstrate the possibility of its revolutionising science. A competent authority has calculated that there is stored in a single grain of radium sufficient energy to raise 500 tons to a height of one mile, and for an ounce of it to drive a thirty horse-power car round the world.

Its potentialities as an illuminant, too, seem

boundless—even the blind are made to "see" its light. Most important of all, as a curative agency in disease radium seems destined to take a commanding place. Already certain forms of cancer have been cured by its aid, and we are only at the beginning of our knowledge as to its wonder-working attributes.

Ideas Beget Ideas. Such are some of the ways in which the ideas of thoughtful men benefit the race, and, step by step, bring us nearer to the millennium. Every discovery begets more discoveries. Pasteur's investigation with the sour wine and beer gives us antiseptic treatment in surgery; it also makes possible the preservation of food, so that the delicacies of the four corners of the earth may be brought to augment the meagre resources of our own little land and our indifferent climate. Berthelot, to assist in the defence of Paris, invents explosives which prove of such importance in industrial arts that their value for the purposes of warfare becomes by comparison insignificant. Maxim, during his service in the great Civil War of America, has the idea of his machine gun "kicked" into him, as he expressed it. The "kick" of the rifle was so much wasted energy; he conserved that energy to make the most formidable fighting weapon of its character then known to the world. The builder of the Tay Bridge, warned by the tragic failure of the man whose effort had preceded his, has to formulate a new plan. Its execution is beyond the capacity of the tools at his command. He invents his tools as he proceeds, and, incidentally, a new industry springs up from this unsuspected source of wealth. There was a call for new implements, though its existence had not occurred to him.

Ideas which were Rejected. There is always a call for new ideas. Statecraft needs them; the empire of business needs them more. The pity is that a brilliant idea may at times be turned to evil account. Joseph in Egypt was the father of "corners." His beneficent prudence saved Egypt in the day of famine. Unhappily the idea has been seized upon by the unscrupulous to make profit at the expense of the many—to "corner" the food of the people. It is to the credit of the British Government that it has before now rejected brilliant ideas which might have been applied to the arts of war. The war-plan of a former Lord Dundonald was refused as being too terrible to employ against civilised foes; and, upon the same grounds, the invention of Lord Playfair for the discharge of shells which set fire to ships and garrisons, and asphyxiate an entire corps or crew, was shelved. Many terribly ingenious plans for war are banned for the like reason. The inconsistency of it appears in the fact that while an army may not poison the drinking supply of an enemy, any public or private body may with impunity poison the rivers in its own country. For the man who can solve the problem of river pollution in England there awaits a rich reward.

The Man of Ideas a National Asset. The day of the dreamer has gone. So many minds are applied to problems that, if the guerdon is to be secured, the man with an idea must see to it that none other comes before him in making plain his discovery. It is to the undying glory of European scientists that all their greatest discoveries are given without money and without price to the world. In America the custom is not always so chivalrous; the aid of patent law is invoked for discoveries in pure science which, if made in England, would be freely laid at the feet of the people. This, however, is a consideration which does not affect the many; the dividing line is sharply drawn between ideas upon which the world has a legitimate claim, and those whose profit should rightly accrue only to their originator. The point is, that all who set themselves to the elucidation of problems, great or small, must seek without delay practically to apply them. Science must now be applied. The scientific recluse to whom his laboratory is the whole world declaims against this theory. But study for study's sake must be the delight of the selfish few. The man of ideas is a national asset upon whom his country has definite claims. It was a discovery of national importance to Germany when her chemists discovered how to make artificial indigo, for they killed India's great trade in the natural product.

The Application of Ideas. There must, then, be no delay in the application of discoveries to their proper use. Procrastination may mean that a man who rightfully should be acclaimed a pioneer may become merely a follower. Great minds run frequently upon similar ideas. The memoirs of Darwin and Wallace on Natural Selection were read upon the same day before the Linnæan Society; Cros and Ducos de Hauron simultaneously communicated their process of indirect photography in colours. Graham Bell was only two hours ahead of Elisha Gray in patenting the telephone. Many other instances might be cited of simultaneity in discovery. In every field the searchers are busy, but there are many mines yet to be located.

For the art of war initiative and organisation are ever commanded. For the arts of peace there must be even greater alertness. The case remains as Pasteur put it: "Two opposing laws seem to be in contest. The one, a law of blood and death, opening out each day new modes of destruction, forces nations to be always ready for battle. The other, a law of peace, work, and health, whose only aim is to deliver man from the calamities which beset him. The one seeks violent conquests, the other the relief of mankind. The one places a single life above all victories, the other sacrifices hundreds of thousands of lives to the ambition of a single individual. Which of these two laws will prevail? God only knows! But of this we may be sure, that science, in obeying the law of humanity, will always labour to enlarge the frontiers of life."

To be continued

Group 12
MECHANICAL ENGINEERING
2

MATERIALS AND MECHANISMS

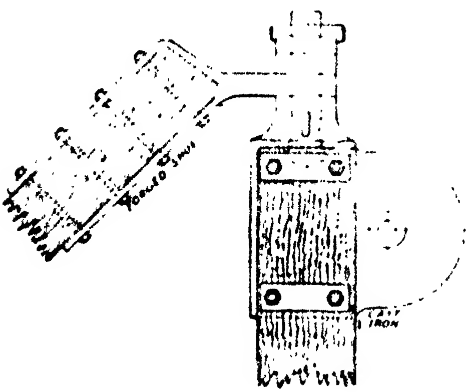
The Study of Applied Mechanics—continued. Beds and Framings. Mechanisms and Materials. Rigidity and Elasticity in Mechanisms

By JOSEPH G. HORNER

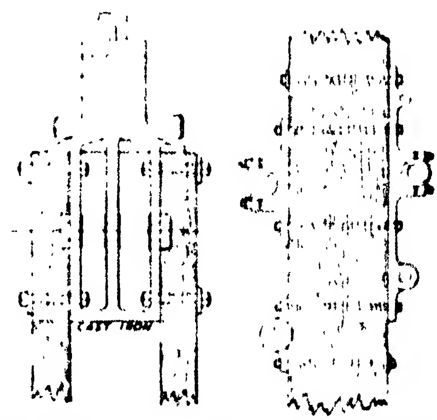
IT is not intended to consider here the strength of materials in the abstract, from the point of view of tests, and of the character of the various stresses to which they are subject. That is being done in the Course on MATERIALS AND STRUCTURES. What is proposed here is to observe how materials are selected and employed in the construction of machines, with a view to the utilisation of their characteristics to the best possible advantage.

It is necessary to remember some points mentioned in the preliminary chapter of this Course, especially those concerning economical manufacture and suitable factors of safety. The design of machinery can never be regarded apart from manufacturing conditions, and the machine tools and of steam engines. Those of machine tools have to be large enough to receive numerous heads, slides, and spindles, those of engines must combine supports for cylinders and slides, and bearings for shafts and spindles. In modern practice nearly all mechanism tends to greater complication, machines increase in dimensions, rendering modifications in design necessary, one of the principal of which is that massive framings often have to be built up in several separate pieces, united with bolts.

Design of Beds and Framings. In considering, first, the design of beds or framings one would like to know how to apply the lessons on the strength of materials which are gathered



1. MAST AND GUY OF TIMBER-FRAMED DERRICK CRANE, CONNECTED WITH A CASTING AND A FORGING.
The forging is in severe tension.



2. MAST OF TIMBER-FRAMED DERRICK CRANE
Fitted with cast iron bearings

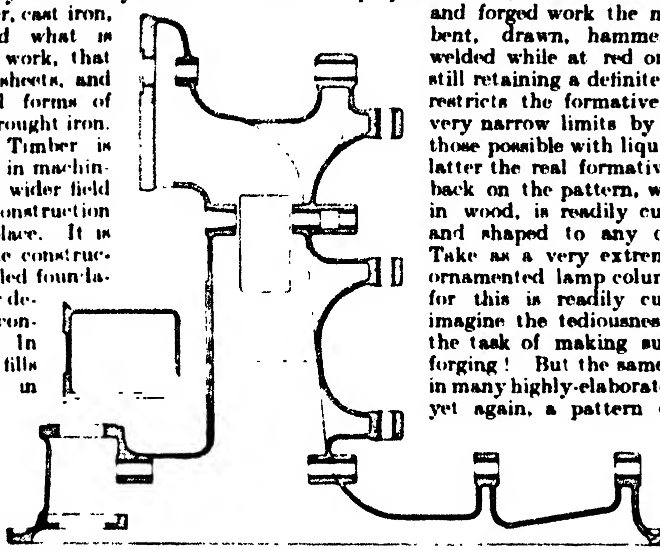
testing machine is but a basis upon which design is embodied by the aid of that experience which cannot be disregarded.

The Basis of Mechanisms. We have seen that a movable mechanism is properly distinguished from the rigid base or the framing to which it is attached, both of which in combination comprise a machine. This distinction is very important from the point of view of materials used. Generally a base, or a bed, or frame is massive by comparison with the mechanism which it carries. It is, moreover, almost invariably of much more complicated form than any of the single elements of which the mechanism is built up, because its form has to be designed to receive the various points of attachment of those elements. Familiar illustrative examples occur in the framings of various at the testing machine. It is as well to caution the student that very precise results are not attainable in this direction. That is, though the testing machine shows that cast iron, say, is capable of sustaining enormous crushing stresses of 40 to 50 tons per inch, it would not do to make a machine framing subjected to such stresses very thin and light by calculations based on tests. If you look at an approved design of bed or frame you see that though it may never be subjected to more than a few tons of load, it is so designed that the imposition of hundreds of tons would be required to crush it. This is due to several causes, such as complications in the stresses, the principal kind being that of the setting up of vibrations of more or less intensity; the rapid changing of stresses from one kind to another, and also the imperfections inseparable

from manufacture, these being of an incalculable character in some cases, as when hidden defects occur which no test piece could reveal. No cautious engineer ever assumes absolute soundness in work: he systematically regards it all with suspicion, and then allows a large margin—*factor of safety*—for the unforeseen contingencies which experience tells him are practically certain to arise sooner or later. Metal is not massed out of caprice, for it is such expensive stuff that the aim always is to use as little as possible consistently with safety, but the trained designer knows that in many cases it must be *lumped*, because his experience reminds him of cases where a cheese-paring economy in this direction has resulted in costly failure.

Materials Used in Framings. *Considering the materials used in beds and frames,* we find that they are strictly limited in number. They are timber, cast iron, cast steel, and what is termed plated work, that is, plates and sheets, and rolled sectional forms of mild steel, or wrought iron.

Timber. Timber is very little used in machinery, but in the wider field of mechanical construction it fills a large place. It is employed in the construction of roofs, piled foundations, and other departments of contractors' work. In machinery it fills a useful place in some truck framings, in some crane framings, receiving attachments of metal [1 and 2], but it has been largely displaced by the plated type of construction, or by that in which rolled joists and other allied sections are used.



3. EXAMPLE OF A "BOX" TYPE OF CAST FRAME, HAVING NUMEROUS BOSSES FOR SHAFT BEARINGS.
The bearings are bushed with bronze.

Cast Iron. This is the material which is employed to an immensely greater extent than any other for machine bases and framings. The reasons for this are the following.

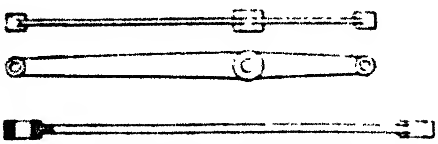
It is cheaper than any other cast material, costing in the form of castings from £8 to £12 a ton on an average. Some exceptionally intricate work may run up to double these sums. It is, therefore, not so cheap that it can be used in a reckless fashion. But steel castings are about twice as expensive, and so is average plated work.

The fact, too, of a bed or frame being produced by casting practically limits the choice to iron in very many cases. Looking at a complicated framing [3] having bearings, bosses, lugs, bracketings, etc., standing out in awkward positions, the fact becomes obvious that by no other method than that of producing the shape in a mould, and pouring in liquid metal, could an economical construction be practicable. This is different from saying that it is impossible—it is only, commercially speaking, impracticable. Therefore, we find that in those cases where framings are produced by building up with plates and rolled sections, these are only adopted in relatively simple designs, or else designs are modified to embody simplicity. Hence in these, of which many crane beds and framings afford excellent examples, the plated work is all plain, comprising mostly rectangular outlines; and awkward shapes are made in the form of small castings, and bolted to the plating [18].

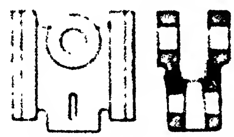
The great advantage of casting is, of course, due to the fact that the metal is poured while in a liquid state, so that it will fill any impression prepared for it, however intricate. In plating and forged work the metal can only be bent, drawn, hammered, rolled, cut, welded while at red or white heat, but still retaining a definite solid form. This restricts the formative processes within very narrow limits by comparison with those possible with liquid metal. In the latter the real formative work is thrown back on the pattern, which, being made in wood, is readily cut, and built up, and shaped to any outline whatever. Take as a very extreme case a highly ornamented lamp column. The pattern for this is readily cut in wood, but imagine the tediousness and expense of the task of making such a column by forging! But the same contrast obtains in many highly-elaborated framings. And yet again, a pattern once made, does duty for scores or hundreds of similar founders' moulds, while a piece of plated or forged work stands alone in its manufacture.

Value of Rigidity. Another good reason why cast work is preferable to plating for main framings is that it is more rigid. The reason lies in the fact that mild steel and wrought iron are immensely more ductile and elastic than cast metal, and they, therefore, vibrate much more under variable stresses than cast metals do. This is a very important point, because vibration is one of the worst evils that can be present in almost any machine or engine. In machine tools the sole reason why beds and frames are stiffened up so enormously in excess of that required for mere strength is the elimination of all traces of vibration. Most of these framings are perhaps from fifty to a hundred times stiffer than they need to be if mere strength to resist fracture were alone considered. A mere trace of vibration would result in chatter and inaccurate work, and would produce wavy marks on the cut surfaces. This necessary

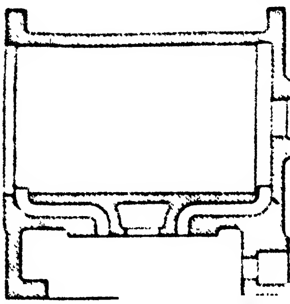
rigidity can be obtained with far greater certainty in cast than in plated or forged work.



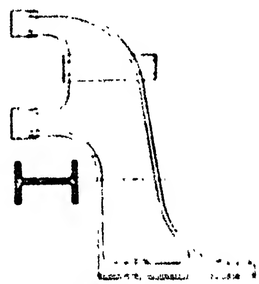
4. LEVER AND COUPLING ROD.
Would be too brittle if cast, but when forged resist tensile and bending stresses.



5. AN ENGINE, OR PUMP CROSS HEAD.
Made indifferently by casting or forging.



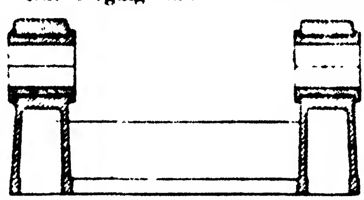
6. AN ENGINE CYLINDER.
In making this, casting is the only practicable method.



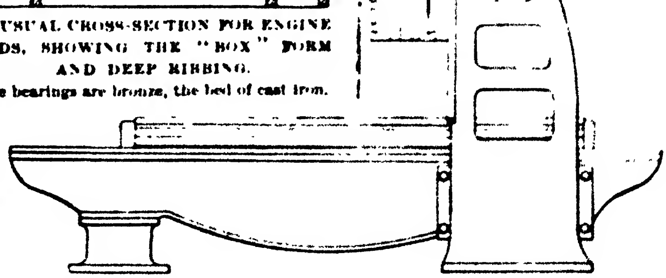
7. RIBBED FRAMING
This has been nearly superseded by the "box" type

Castings *versus* Forgings. If, again, we compare castings with forgings, we see at once the reasons why each occupies a different sphere of utility from the other. Forgings are not so readily made as castings unless large quantities are required alike, in which case die forging effects immense economies. But forging and casting each occupy a distinct and strongly-separated sphere. A casting is rigid and brittle by comparison with a forging, and is therefore to be preferred when rigidity is essential. A forging is tough and ductile, and is, therefore, employed for pieces of small section, as rods, levers [4], small cranks. There is a border line where either is used indiscriminately, as in small pieces of many kinds, used in all mechanisms, and subject to comparatively little stress [5]. In these, die forging comes into increasing rivalry with castings. But in the main portions of engines and machines there is seldom any question as to which should be employed. Casting scores in all cylindrical work subjected to much wear and stress, and having many branches, holes, and passages. Among the best examples of this kind are engine cylinders [6] cored out; hydraulic cylinders, and pump barrels, typical of many others. It would be practically impossible to produce such forms by any forging methods, although where lightness is an object sought, much intricate forging is done by bending and welding. But it is costly, and the rigidity obtained in castings is another reason why the examples just mentioned must be cast, even if it were practicable to forge them.

Arrangement of Metal. There is, however, another reason for the superiority of cast to plated work for framings, besides that due to the difference in the ductility and elasticity of the materials. It is due to the fact that the metal can be arranged in a very economical and efficient fashion in a casting, by making the latter hollow, a case which is paralleled in the hollow form of columns. At one time most framed castings were plainly plated, and ribbed round the edges [7], now such a gaunt wasteful design would not be tolerated in heavy machine framings. It is well understood that a given amount of metal massed in a solid column will, if arranged in the hollow form, be much stronger. So in all hollow machine framings, termed the boxed type, the maximum of massiveness, strength, and general rigidity is combined with the minimum of material [8 and 9]. It is a by-issue that in many of these the interior is utilised for cupboards



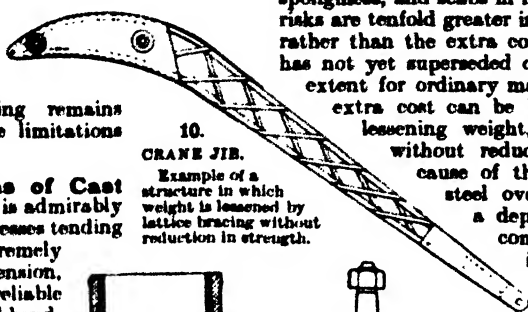
8. USUAL CROSS-SECTION FOR ENGINE BEDS, SHOWING THE "BOX" FORM AND DEEP RIBBING.
The bearings are bronze, the bed of cast iron.



9. PLANING MACHINE FRAMING WITH PARABOLIC TYPE OF BED AND HOUSING.
The form best qualified to resist bending stresses.

and shelves; the boxed form preceded those utilities.

We understand now, therefore, why cast iron is used for the majority of framings, and why these are made massive, and generally of hollow form. But something remains to be said about the limitations of cast iron.



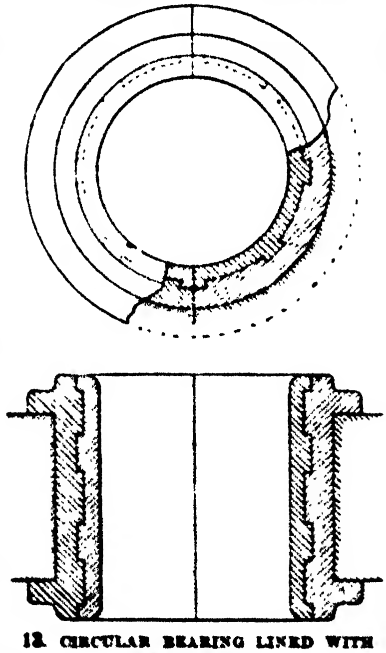
10. CRANE JIB. Example of a structure in which weight is lessened by lattice bracing without reduction in strength.

The Limitations of Cast Iron. This material is admirably suited to withstand stresses tending to crush, but it is extremely weak if subjected to tension, and is not thoroughly reliable to resist transverse and bending stresses. These differences have to be taken account of in design. Cast iron is loaded directly to an almost unlimited extent, but it is rarely subjected to a direct pull. It is often subjected to cross bending, but the factor of safety must be high in that case, and the nature of the loading must influence the factor. A perfectly quiet or dead load is the most favourable, a vibratory or live load is risky. But by increasing the depth of a section [see the bed *A* in 9, and parabolic housing *B*] which has to be subjected to bending stress, ample strength may be secured, because strength increases directly as the square of the depth. This in conjunction with the requirements of rigidity just discussed explains the reason of the depth given to horizontal engine beds, to long lathe beds, and allied designs.

Cast Steel. The only serious rival to cast iron for framings is cast steel. This would be used to a much greater extent than it is but for the difficulties of producing sound castings. The value of the material lies in its greater strength to resist all kinds of stresses, tensile and transverse as well as compressive. The writer has a vivid recollection of early attempts to substitute steel for iron in parts of crane work. It was impossible for many years to produce the most ordinary steel castings free from blow-holes, while many were cracked locally in addition.

11. PUMP BARREL. Made of cast iron, lined with brass.

12. AIR PUMP ROD. Of rigid steel, sheathed with brass to prevent rusting.



13. CIRCULAR BEARING LINED WITH WHITE METAL. Held in dove-tailed grooves.

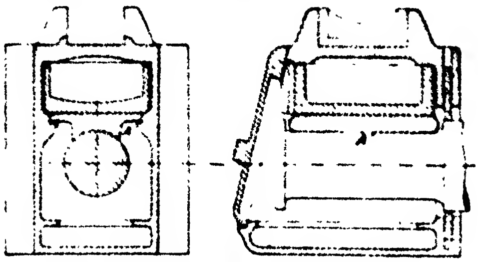
These difficulties, well-nigh heart-breaking to the steel founders, are not yet entirely overcome. There is always some risk of blow-holes, sponginess, and scabs in iron castings, but these risks are tenfold greater in those of steel. This, rather than the extra cost, explains why steel has not yet superseded cast iron to any great extent for ordinary machine framings. The extra cost can be largely discounted by lessening weight, which can be done without reduction of strength, because of the greater strength of steel over iron. But directly a departure is made from comparatively plain castings, equally proportioned in their various parts, shrinkage stresses come in to complicate the difficulty of making sound castings free from blow-holes.

Lessening of Weight in Framings. There are other cases now to be considered in which an entirely opposite condition exists, in which the object is not to mass metal, but to reduce it as far as possible, consistent with safety. It occurs chiefly in designs of which the bridge is the best type, and which it is necessary to lighten as far as practicable, because the weight of the structure itself forms a considerable percentage of the load which it has to sustain.

At one time nearly all wrought iron bridges were formed of solid or continuous plates, a most wasteful design, because the metal over very large areas was altogether far in excess of that necessary for security, and represented, therefore, so much useless load which the bridge had to carry. In a modern lattice girder bridge there is not more metal used than is required for safety. The lattice bars and booms are never arranged in a fanciful style, but the strength of every individual bar is calculated for the loads that will be imposed on it, both in nature and intensity. Thus a bridge with a maximum of strength and the minimum of weight is obtained. And what is done in the bridge is done also in all structures in which a similar principle is involved. It applies to the lattice beams of overhead travelling and bridge cranes, to the jibs of cranes [10], to the inclined hoist

ways of blast furnaces, to the columns of gas holders, and railway station roofs, and to the roof principals when these are built of steel.

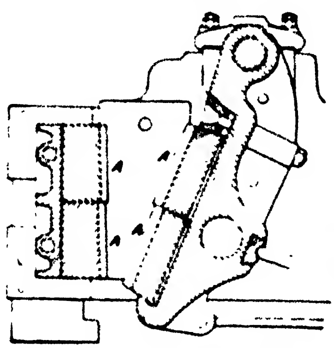
When speaking of materials it is not possible to pass over without remark the revolution which the use of mild steel as made in Bessemer and open hearth processes has effected in the design of machinery. First, the heavy timber work of the old millwrights gave way to cast iron, and this to wrought, to be displaced by steel. The result is an extended and ever increasing employment of the latter, with diminution of weight and more elegance of form.



14. AXLE BOX FOR RAILWAY WAGONS.
The main box is made of cast iron or steel, but the actual bearing A is of bronze or of white metal.

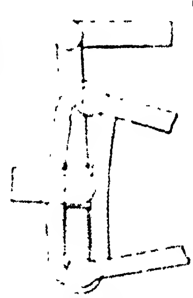
15. CAST IRON TROLLEY WHEEL.
Chilled around the tread to lessen wear.

Essential Mechanisms. We next consider the selection of materials for the actual mechanisms, regarded apart from their bases, and soon find that conditions are much more varied in these than they are in those which control the selection for the bases of machines. To the questions of stress and strength are added the problems of movements of various kinds, the turning and sliding referred to in the previous article, with the involved problems of friction. Each of these offers separate difficulties, and all must be overcome in detail in the production of a practically perfect and workable mechanism.

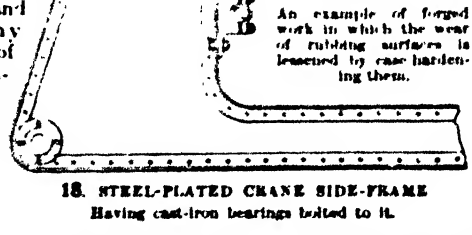


16. JAWS OF STONE BREAKER.
Having removable pieces, A A, of manganese steel for durability.

Materials. Into the construction of moving parts many materials enter. They include cast iron and cast steel, forgings in iron and steel, very many grades of alloys of copper, tin, zinc, aluminium, etc., with minute admixtures of other elements, and made up in the forms of castings, bars, rods, tubes, sheets, some of which, too, are subjected to special treatment, as hardening and tempering. Let us note the principal conditions which have to be fulfilled in the moving parts of mechanical structures.



17. REVERSING LINK MOTION.
An example of forged work in which the wear of rubbing surfaces is lessened by case hardening them.



18. STEEL-PLATED CRANE SIDE-FRAME.
Having cast-iron bearings bolted to it.

It is of the very greatest importance to consider the general question of strength. The first and most essential condition to be fulfilled is apparently, as in the base or frame, strength to resist stress and strain, or deformation and fracture. This is a very comprehensive way of putting the matter, because the term strength is so very embracing and covers so much of detail. It may be strength to resist compression, or tension, or bending, or torsion, or steady loads, or variable loads. First, then, the nature of the stress for each member must be ascertained, and its amount estimated with as close an approximation to facts as possible, and then the suitable material selected and duly proportioned.

Rigidity and Elasticity. With few exceptions bodies are assumed to be rigid, using the term in its practical sense. When a body yields to stress and becomes deformed in consequence, the degree of elasticity by virtue of which it has yielded is of great importance, because it must in no case be such that it remains a *permanent set*. On the removal of the stress, the elasticity must be equal to the complete removal of the deformation. This, therefore—the elastic strength of the material—measures its capacity to resist stress, and not the actual or absolute strength to resist fracture, and it is a fundamental distinction ever to be borne in mind in designing mechanisms.

Now, some materials are more rigid than others, and some are better qualified to resist one kind of stress than another, and this is the reason for the selection of one or more materials in preference to others for given duties.

Cast iron, as we have seen, will not endure much tensile stress, and therefore it is rarely employed in such service. But forged materials, and some cast alloys, as those of copper and tin with phosphorus, or with aluminium, will, and these, therefore, are materials used largely in parts subject to tensile stresses, such as moving rods of various kinds, in pumps, engines, and mechanisms generally. They lack the rigidity in compression which castings possess, and therefore if used as compressive members their area must be calculated on a liberal basis.

Cost. The grading of materials by alloying elements in which iron and steel are included gives the designer any kind of material required for a given duty, hard and tough, or hard and strong, or elastic, as best adapted to resist the stresses imposed, and much of the art of the designer lies in making a suitable selection from the wealth of materials available.

Here again the question of cost acts as a corrective. Often a very desirable material has to be discarded for one less suitable because of the difference in price. But there are many dodges practised which are more or less familiar, such as making parts in sections, facing or supplementing a cheaper with a more costly material, as in some pump rods and barrels [11], a plan which is adopted for other reasons also, as in frictional devices.

Friction. The division in our first article of elementary mechanisms into turning and sliding pairs suggests the problem of friction. There are mechanical devices such as lubrication, the use of long bearings, ball, and roller bearings with a view to lessen friction, but materials also are selected with this object. Steel may run with steel, turning on balls or rollers, but not with sliding surfaces. A steel shaft or cross head must move in cast iron, or on a bronze, or brass, or a white metal alloy. But cast iron may slide on cast iron, or on either of these alloys. Wrought iron will not slide well on wrought iron, but it will on cast, or on brass. The diminution of friction is essential to the durability of a moving mechanism, just as the strength of the material has to be correlated to stress to prevent deformation of fracture. 12 to 14 are familiar examples of designs to diminish friction.

Hardened Surfaces. Intimately associated with the question of durability is that of certain mechanical processes by which the physical characteristics of materials are changed. We allude to hardening processes effected by the smith or the foundryman. When a surface has to be subjected to prolonged and severe friction it is rendered as hard as glass, either by taking advantage of the presence of carbon or by impregnating its surface with carbon. The first is the hardening of the smith effected by quenching red-hot steel in water. It is also the method of the iron founder, who rapidly changes the carbon from the graphitic to the combined condition, by chilling—i.e. pouring the metal against a cold iron surface which forms that portion of the mould. The chill only extends to a depth of from one-eighth to half an inch or thereabouts [15]. Or loose jaws of hard steel are fitted as in the stone breaker [16], or in the bottoms of mortar pans. The second is the method adopted when a forging contains no carbon, as in wrought iron and mild steel. A surface coating of carbon is produced by case hardening—that is, subjecting the forging to the influence of carbonaceous substances in the presence of nitrogen in a closed box maintained at a red heat for several hours, as in the link motion 17.

Factor of Safety. The factor of safety, already mentioned several times, is so important a subject that it calls for some observations of a practical character. This factor signifies the difference, the relation, or ratio between the safe working load and the ultimate or breaking strength of a structure. It may, however, be conveniently taken as the relation between the working load and the elastic limit, or elastic strength, and if so, that must be clearly stated. But in either case it means that when the strength of a structure or a part of a mechanism has been arrived at by calculation or test, it must never be subjected to any stress corresponding with that strength, but to a lower stress, often very much lower.

Methods of Loading. It is well known that the stress that strains least is that of a dead load, or a load which does not change either in intensity or character. The load on foundations and piers is of this character, and so generally is that on beds and baseplates carrying machinery. Here the factor of safety is low, often not exceeding three in iron and steel—that is, the structure would be made three times stronger than the calculations for strength would give. It is higher for materials liable to decay, as timber, for which it may be from seven to ten, or to bad jointing, as masonry, where it might range from ten to twenty.

But when the load is a live one, the factor must be higher. A live load signifies one that is being imposed and removed constantly. One of the most trying loads of this kind is that of soldiers marching over a bridge, hence the reason why they have to break time then. A terrible accident happened once to a bridge in France due to the marching of soldiers in time. Another severe live load is the rolling load of a train running over a bridge. So is that of a jenny running across a travelling crane. In these cases the dead load factor is doubled, or trebled generally, doubled if the stress is of one kind only, and often trebled or nearly so if of two kinds as tension and compression alternating.

Yet again loads may be impulsive, or of the nature of sudden shocks, such as occur in the lifting of crane loads, with the rapid surgings that are set up. These are incalculable, and in such cases factors of safety of from ten to fifteen or even twenty are allowed in some members, or from three to four times as much as for dead loads. Very often, therefore, crane framings are made of plated steel and the bearings only in cast iron [18].

But more has to be considered yet in fixing this factor. As we cannot always calculate the nature and intensity of the stresses on a structure, the value of experience comes in to determine how much to allow. And yet again the quality of material and of the workmanship has to be taken into account, until at last we find that the results arrived at with the testing machine have gone but a little way in helping the designer, who has to apply this knowledge to workable mechanisms.

Variations in Materials. This last remark opens up another broad field about which a big volume might be written, the variations in materials nominally alike, and in the character of the workmanship put into mechanisms. These are quite as important as any of the other conditions already discussed in determining how much a machine may be trusted to perform and endure.

It is because materials, nominally alike, vary so greatly in strength, ductility, soundness, and other characteristics that specifications are often made very strict, and inspectors appointed. We may have some cast iron twice as strong and tough as other cast iron, and similar differences will be found in other metals and alloys. A nice clean test piece of timber an inch or two inches square and a foot long and free from shakes and knots, gives but a misleading idea of the strength of a commercial balk a foot square and twenty feet long. Neither does a test bar of cast iron tell anything about the condition of the interior of a heavy casting poured from the same ladle. And, further, most materials deteriorate in the course of years, notably timber, but also iron and steel and the rest. They are subject to fatigue, due to overwork, and then bend or break under a much smaller stress than they have successfully endured millions of times previously. They may become corroded, with diminution of section, and all these things must be taken account of. Because of this, factors of safety are often made high in the first place, and working loads reduced from time to time, just as is done regularly in steam boilers.

Workmanship. With regard to workmanship, this enters into all practical determinations of factors of safety. It applies to castings which often have hidden faults, to the processes of welding, punching, and reamering, to the drilling of rivet holes in bridges, to boiler work, to methods of riveting and caulking, to the nature of the fitting on engines, and to machinery involving an immense amount of detail. A badly made mechanism will soon knock itself to pieces, a well fitted article has a long life before it. These facts, barely mentioned here, indicate the need for an extensive acquaintance with shop practice on the part of the designer. He must know the faults incidental to the work of foundry and forge, of the turnery and machine shop, and of the fitting and erecting departments.

The Curve and Fillet. There is another aspect of design which, though it may appear of small moment, is yet of very great importance, namely, the employment of the curve and fillet instead of the keen angle. Angularity is not only an eyesore, but it is a great element of weakness. Put a radius in a re-entrant or internal angle, and the chances of fracture through that angle are vastly lessened. This is not due to the slight extra metal hardly at all, but to the better arrangement of the crystallisation which results. It is most apparent in cast metals where crystals arrange themselves normally to the cooling surfaces. But in forgings it results from the continuity of the fibres not being broken, which is the reason why fullering tools never have square edges, but always convex ones.

Facilities for Repairs. The designer of mechanical structures has to regard another matter—an entirely practical one, that of affording suitable facilities for building up, and taking apart a mechanism for repairs. When these are necessary—and they inevitably arise in all kinds of mechanisms—the more rapidly this can be effected the less will be the delay and expense. Many draughtsmen would fail in this if left to themselves. The subject is too wide to be illustrated here, but briefly it involves the designing of a mechanism in such a way that it shall not be necessary to dismantle it all to effect a slight repair. That is, if a shaft or broken wheel or a valve has to be removed, it ought to be possible to do so without pulling the whole thing to pieces. Good designers bear this in mind, others do not.

These are some of the practical every-day aspects of a subject that looms large in the applications of practical mechanics. It is as important to understand the characteristics and the faults and weaknesses of the metals and their alloys as to know how to estimate the nature and intensity of the forces acting on mechanical elements. The behaviour of materials at the testing machine is but one side of the subject. That of their characteristics developed in manufacture through the various shops is of equal importance, and this knowledge is gathered in the foundry and forge, in the turnery and machine shop, in the mechanism in course of construction, and when under final test.

To be continued

Group 29
TRAVEL
2

THE PERSONAL VALUE OF TRAVEL

Travel as an Essential Factor in the Development of Mind. A Means of Joy and Profit. Its Mental and Utilitarian Side

By J. A. HAMMERTON and WILLIAM DURBAN, B.A.

TRAVEL is one of the most effective factors in the development of individual character. That greatest of English schoolmasters, Arnold of Rugby, used to say that he always found that the boys who had never visited London, and who had never caught sight of the ocean, were the most difficult to impress with any notion of the greatness of the world and the stupendous possibilities of life.

The genuine scientific phrenologist and the sound metaphysician both alike testify that the exclusive cultivation of the faculty denominated "inhabitiveness" tends to dwarf the mind. Home becomes dearer after some amount of nomadic experience, and, as "change is the spice of life," according to a very sensible standard of philosophy, nothing is so perfectly calculated to refresh the mind as change of scene. It is a fallacy to imagine that travel far and wide in any degree weakens the delight that the finest natures take in the amenities of domestic life. The exact contrary is the case. The true human soul is finely poised in its emotional equilibrium, and, unless distorted or decadent, it balances evenly the love of continuity and the desire for change.

What Great Men Owed to Travel. The relation between character and travel is remarkable. The vast majority of the ruling spirits of the world have derived their matchless qualifications, in no small degree, from the enlarged knowledge of men and things gained by actively and extensively moving about the world. Catherine the Great is not usually reckoned among the much-travelled women of history; but she knew her native Germany well before she went to Russia; and after her accession she frequently took immense journeys through her vast dominions, toilsome though such pilgrimages were. The most renowned conquerors and the grandest nation-makers have in all ages been amongst the most adventurous travellers. No Roman ever saw so much of the Empire and of the regions beyond its various borders as Julius Cæsar. Little Greece could not hold Alexander, and it was by marching far away into another continent that he became "the Great." Paul, the greatest of the Christian Apostles, was one of the greatest travellers of early ages, and he it was who consolidated Christianity. Napoleon, before he gained renown and attained to Imperial power, knew Italy almost as well as France, and had made intimate acquaintance with Syria and Egypt. His rival and conqueror, Wellington, had roamed about India before he was called on to lead our forces through European campaigns. Nelson not only took his victorious squadrons to the shores of the Levant, to the coasts of Egypt, to Italy, to Denmark, to Teneriffe, and to the West Indies, but he everywhere showed an enthusiastic interest in the countries and the peoples he thus visited. As a young midshipman he had the privilege of an Arctic voyage, which helped immensely to enlarge his mind.

We only have to go back, in the history of great men, to a few memorable names, and we begin afresh to see how wonderfully foreign travel, as well as wandering in the most interesting realms of one's own land, must have influenced the development of intellect. Milton knew and loved Italy when to visit that fair land was no mean undertaking. He could write Italian poetry almost as well as a native. We should never have had Longfellow's matchless prose romance, "Hyperion," but for his extraordinary familiarity with Germany. Few books on European travel are so delightful as the "Views Afoot" of that vivacious American, Bayard Taylor, who walked thousands of miles in Europe when a mere lad. Browning is the poet of other lands as well as of England, and by his easy familiarity with international social customs became what Dean Farrar in his great lecture called him, "the poet of universal humanity."

Modern Leaders and Travel. Do Englishmen generally appreciate the fact that King Edward gained the most valuable part of his education when, as Prince of Wales, he visited America and then India? His Majesty is as much at home in France and in Germany as in England, and he doubtless owes his broad popular sympathies to the fact that his numerous journeys and frequent sojourns abroad have totally precluded any tendency to insularity in his sentiments. The present President of the United States is astonishing the world by his versatility of resources and his boundless interest in the welfare of humanity generally. Who can imagine that if Theodore Roosevelt had vegetated in the money-making sphere of his New York Knickerbocker circle, in which he was cradled in comfort and affluence, he would have been the power for good that he is? Mr. and Mrs. Roosevelt were married in London, and they know it as well as they do Washington. Oyster Bay and Nevada, Cuba and Oregon, are equally familiar to this distinguished American, who admirably represents the national tendency to see the world and to study it sympathetically.

Tolstoy in his old age stays at Moscow or at Yasnaia Poliana, but in his younger days he was a great roamer, and if anyone wonders at the enormous influence of Maxim

Gorky, let it be understood that this new genius of literary Russia has spent his whole time in the most romantic wanderings in his vast fatherland. George Meredith, our greatest living novelist, was, as long as his strength allowed, an ardent traveller and pedestrian. Rudyard Kipling, too, owes much of his success to his travels throughout our Empire.

Travel Essential to Culture. Culture without travel is largely a failure. It is irreparably defective in certain directions. The history of the Popes is a lurid illustration of this principle. Some of the Pontiffs have been men of real genius. The late Pope was reckoned the finest Latin scholar in the world. He could write Latin poetry equal to that of Horace himself. But even the most charitable of his own partisans could not pronounce Leo XIII. other than the narrowest of reactionaries. He spent long years in the seclusion of the Vatican. How mighty would be the influence of a Pontiff who could traverse Christendom! The power of the Bishops in Anglican, Roman, and Greek communions depends to a very great extent on the manner in which they see this and that part of their Sees. The late Archbishop of Canterbury, in the days when he was Bishop of Exeter, gained extraordinary personal sympathy amongst the farmers of his great diocese through his constant journeys in his diocese and his zealous interest in their affairs. Christianity began with travel, and it can be propagated in no other way.

Simplicity in Travel. Simplicity is one of the essential conditions of real enjoyment and profit for the traveller. The tourist who knows nothing of the simple life must miss many opportunities of the most desirable kind for making acquaintance with life in its most varied and interesting aspects. It is true that not many of us may feel disposed to emulate the example of Oliver Goldsmith, who allowed the want of means for providing comforts to constitute no impediment to his passion for wandering. He absolutely revelled in the simple life. When his funds were exhausted in Dublin he wandered on to Cork, where, when he was in great distress, a handful of peas was given him by a girl at a wake, the flavour of which remained for ever sweet in his memory. Few men so intimately blended the pleasures of the simple life with the most romantic modes of travel. Goldsmith wandered over wide districts of Europe on foot, scantily provided as to purse and wardrobe, but rich in his kindly nature and his wonder-working flute. Travel is peculiarly adapted to the cultivation of simplicity. It is best enjoyed by those who love "plain living and high thinking." Byron and Shelley*well understood this. The former enjoyed nothing better in his strange career than his sojourn amongst the monks of the Armenian Convent on the Venetian Lagoon for six months, while he studied their language; unless it was the series of his wanderings in wildest Greece, where he revelled in the rough mountain life of the peasants battling for independence.

Untrammelled Travel. We have known the luxury of going over the Dovre Fjeld without any impedimenta beyond a tiny parcel, for who could roam about that magnificent wilderness near the Arctic with the baggage which some tourists seem to think indispensable everywhere? We have journeyed many thousands of miles awheel carrying all our baggage on our bicycle. "Through Norway with a Knapsack," as Williams's charming volume is entitled, suggests one of the ideal methods of enjoying life under the auspices of pure, exhilarating air and of scenery of unspeakable enchantment; while R. L. Stevenson's "Travels With a Donkey" and "An Inland Voyage" are almost lyrical in praise of the simple life in travel.

Travel teaches us that many of the artificial trammels of civilisation are purely superficial and negligible quantities. Every winter explorers like Professors Petrie and Sayce go back from Oxford and London to the East, and spend months in company with the poor native fellahin in Egypt or the nomad tribes of Arabia, leaving the luxuries of the West behind, and revelling in the discoveries that reward their quest. The simple life is being lived by a larger number of people than is generally supposed, but those who observe the very simplest conditions are the great travellers. It is the freedom from the complications and the needless accessories of ordinary home life, evidenced on every page of such records, which gives an indefinable charm to books like those of the late John MacGregor, "The Rob Roy on the Jordan," "The Rob Roy in the Baltic," etc. And from Du Chaillu, in his "Land of the Midnight Sun," many a reader has been set longing for an experience of a holiday among the Scandinavian "saeters," where simplicity is the rule of happy life in fellowship with Nature in her most charming moods.

The Faculties of Enjoyment. We can the better comprehend the utility of travel when we reflect on the measure in which it develops those faculties of purest enjoyment which otherwise may lie altogether dormant. There are perceptive capacities in the human soul which cannot be exercised subjectively, but must have opportunity of objective observation. Nature calls us to admire the infinite variety she has to show. She constantly changes the diorama. But harmony prevails everywhere. Mountains bathe their feet in the depths of crystalline lakes. Artists are captivated by the blending of the most contrasted scenes of sublimity and tenderness in Tyrol and the Dolomites, in the black lava fields of Sicily and the vineyards caressing them round the vast base of Etna. Sympathy with life is seen even on the edge of the great ice-pack of Amsterdam Island, for seals sport playfully in the savage waste. No two scenes are alike. The world only tires us if we stagnate in one spot. Said a gentleman living in one of the most beautiful districts of Kent, "All the prospects round here are lovely, but I know them so well!" The longing for change of scene is wonderfully responded to if we will go forth occasionally from accustomed haunts.

"Men love the tale of a traveller who has his eyes wide open," says a recent writer; and this is true, for in almost any company a guest is more than welcome who has seen something that perhaps others have not. People are hungry for freshness and eager for novel information. Those who have been denied opportunities are often very grateful to the traveller who will take the trouble to recite some of his experiences. And members of the younger generation are continually coming up with aspirations for travel; these are specially anxious to be directed and advised. Nothing is more delightful than the reciprocity of feeling promoted when strangers happen to meet who can compare notes of travel. They become friends offhand, and many desirable relationships are thus formed.

The Utilitarian Side of Travel. This is a large subject, which can here only be lightly touched upon. In the Middle Ages thousands of young artists and of candidates for positions in the various learned professions took long and serious tours. Many still do so. But the practice is not anything like as general as it should be. Many people have with great subsequent profit travelled for the sake not only of enjoying a pleasure trip, but also with the view of taking in fresh observations in respect to architecture and building. A young builder visited America and came home with a stock of new practical notions which he proceeded most successfully to apply. Indeed, the professional bearing of travel and its industrial advantages is altogether inestimable. Vivid illustrations in this direction have recently been supplied by the Japanese. Quietly and unobtrusively during the last two decades thousands of young men from Japan have been visiting all the great countries of the West. The results of their keen observation have been stupendous.

An American admiral was recently invited, while his squadron was in Japanese waters, to dine on board the flagship of a Japanese admiral. As soon as the American was seated in the cabin the host rose quickly, flung a napkin over his shoulder, and said, "Do you know me, captain?" The guest started in astonishment, for he at once recognised his former Japanese servant, who had faithfully attended him for a considerable period in American waters when he was a captain. During that period the young man from the Far East had been quietly taking in a valuable stock of knowledge which he had not neglected to apply for the benefit of his own nation.

A singular instance of the great value of travel in the educational sense occurred in the experience of the famous James Nasmyth, the inventor of the steam-hammer. His original drawings of his invention were approved by some steamship builders, but were for a time laid aside. During Nasmyth's absence at one season from the foundry, two visiting French engineers saw the sketches. Two years later the inventor happened, during a Continental trip, to visit the great Creuzot works. Observing an engine crank which could not have been forged by the old kind of hammer, he asked how the work had been done. "This crank was forged by your steam hammer," was the reply. The French engineers proceeded to show the Englishman the hammer they had built from his plans. He was delighted, and on returning home constructed a hammer for himself, soon managed to interest the British Government, and secured large orders.

How Travel Aids Study. Finally, it must be obvious to every thinking mind that travel is unrivalled in its tendency to increase our geographical knowledge, and to fix the mind accurately in the mastery of topographical features. All who have travelled much are familiar with a very singular phenomenon. In the course of a journey we may happen to visit a spot that we had never previously heard of, and are delighted to have discovered it, on account of unexpected features of interest, beauty, and attractiveness. And, to our astonishment, very likely, after returning home and settling down, we come across references to that same place in newspapers, or magazine articles, or books. The truth is, of course, that such allusions would pass altogether unnoticed but for the fact that we had just become familiar with the obscure locality, and so our attention is naturally drawn to what would have been entirely disregarded but for this acquaintance. Travel invests geographical study with living charm and inexhaustible interest, making it altogether another science than the mere collection of abstractions presented to the non-travelled mind. It also greatly enhances the pleasure and profit of our ordinary reading, and an instance of this from our own recent experience will illustrate the point.

Travel and Book-reading. Happening, by the merest chance, to take up Thackeray's "Henry Esmond" during a resting holiday in Scotland, and thus to re-read it after many years, our interest in the story was vastly increased when we discovered, as we proceeded with it, that with hardly an exception we had visited the scenes of Marlborough's battles in the Low Countries, and had that very summer spent some days in the little-known Alsatian town of Barr, which is mentioned several times in the story in connection with the movements of the Pretender. Indeed, we incline to think it is better to read of places *after* one has visited them than *before*; at all events, better to read of them in greater detail after we have familiarised ourselves with the actual scenes. And all who have travelled agree that the law of mental association works with delightful effect after journeys and voyages near or far. For a picture or a description of scenes we have visited will call up whole chapters of our happiest experiences. The mere guide-book without the journey is the dry letter that kills interest; the journey itself is the spirit, the meaning, the substance, the intention of things, because it brings us in contact with life in all its interesting manifestations.

To be continued

FLEECES AND FIBRES OF WOOL

THE MICRO-PHOTOGRAPHS OF THE FIBRES ARE SEVENTY TIMES MAGNIFIED

condition. At the end of the feeding season, when the lambs are three months old, the farm hands gather to the washing. Three long troughs are filled, one with cleansing dip, one with a weaker solution, and the other with clean water. The sheep to be washed will have been penned the night before. In the early morning begins a long day of arduous toil for the shepherds and their helpers. One after the other, the sheep, bleating, struggling, butting, kicking, are soused, scrubbed and washed in the troughs, and then fly off up the fields, shining with a glittering coat. It is considered a wise practice to let two or three days elapse between washing and shearing, because the yolk, dissolved in the soapy dip, gets time to renew itself.

The question "What is yolk?" naturally occurs to the reader, and it is worth attention. Like all animal fibres, wool has a vital function to perform. It is tubular, containing fatty and other matters exuded from the skin. These matters are called, collectively, yolk, and form a considerable proportion of the weight of wool. An eminent chemist has analysed wool, with this result:

Earthy Substance	26·06
Suint	32·74
Fatty Matter	8·57
Earthy Matter fixed by grease	1·40
Wool	31·23
	100·00

It will be seen that yolk is an important matter. When the yolk supply is small the fibre is harsh; without it, the central tube, being empty, collapses, and the fibre splits.

Within three days after the dipping operation the flock is gathered again. All along the field sheds are erected, and within them long benches. At each bench stands a shearer and his assistant, the former holding in his hand a large pair of shears. The sheep is brought, and turned on the bench, and while it is held firmly, the shearer clips. His work demands no little skill. The skin must not be injured, or blood will smear the fleece; the wool requires to be cut evenly, or the staple will be irregular; and the fleece should come off whole. The work goes on with

"the loud-clapping shears,
While ever and anon, to his shorn peers,
A ram goes bleating."

Varieties of Wool. There are at present more than a hundred kinds of wool on the market, and the manufacturer is frequently embarrassed by the wealth of choice. Practical men, however, classify several kinds under one head, and so spare themselves needless worry. For instance, it is quite well understood that Australia sends wool from six states, differing in climate and soil; but the wool appears on the market as one class, with corresponding sub-divisions arranged

TABLE OF VARIETIES OF WOOL PRINCIPALLY USED IN THE WOOL TRADES

Country.	Breed.	Quality.	Length of Staple	Average Weight of Fleece.	Yarn Number	Fabrics.
Spain	Merino	Fine	Short	5 lbs.	50-130	Broadcloths, worsteds, ladies' dress cloths, and all the highest classes of wool fabrics.
Saxony	.. and cross-bred	Very fine	..	—	10-180	
Silesia	.. ..	Finest	..	—	100-240	
Australia	Merino, cross with Leicester and Southdown	Very fine	—	8 lbs.	80-150	
United Kingdom	Lincoln	Good	Long	8-9 lbs.	40-90	Imitation alpacas, lustre, and worsteds
..	Leicester	Fine to coarse	..	7-9 lbs.	20-70	Worsteds and hosiery yarns
..	Romney Marsh	Medium	..	7 lbs.	30-50	Woollens and carpets.
..	Southdown	Fine	Short	3-4 lbs.	40-80	Light dress cloths
..	Dorset	Medium	..	24 lbs.	20-40	Livery cloths, woollens
..	Cheviot	..	Medium	3-4 lbs.	30-50	Tweeds, woollens, heavy dress cloths.
..	Cotswold	..	Long	7-8 lbs	50-70	Cords, worsteds, serges.
..	Blackface	Coarse and strong	Medium	--	10-40	Blankets, carpets, etc.
..	Highland	Coarse and strong	..	—	10-50	Blankets, carpets, etc.
France (South)	Merino & Rousillon cross	Soft, fine	Long	9 lbs.	170-180	Dress goods, merinos, cashmeres.
.. (North)	Cross-breds, various	Medium	Short	-	20-95	Woollens
Algeria	Native sheep	Inferior, but soft	..	-	10-70	Felts, blankets, rugs.
Turkey	Angora	Very fine	Long	-	Finest yarn	Fine cloths.
..	Native breed	Coarse	Short	—	Low counts	Felts and coarse wools.
East Indies	Various breeds	Generally coarse	Short	--	Coarse counts	Carpets, felts.
..	Hooniah	Fine	Long	—	3-80	Ladies' dress goods, shawls.
Russia	Odessa	Fine	Short	—		Worsteds
..	Merino	Very fine	Medium	-	75-18	Broadcloths and serges.
..	Astrakhan	Special character	Short			Astrakhan cloth.
South Africa	Fat-tailed	Various classes	—	--	—	Worsteds, alpacas, woollens.
..	Merino					
..	Angora					
South America	Imported European breeds	Good, but dirty	Medium		90-200	English fine cloths.

not in accordance with geographical areas, but variations in quality. All the wools of Australia and New Zealand have peculiar qualities that distinguish them as a class. Similarly, though some varieties of Leicester wool may closely resemble those of Lincolnshire, the skilled wool-buyer can recognise differences.

Classification. After all, we are users of wool, not students of sheep pedigrees. We can leave aside nice questions of variety and breed, and lend our attention to the useful qualities of the fibre. In old books, it is said that wools are divisible into two classes, carding and combing, the latter being long and the former short in staple. But we find in practice that this classification helps very little. The very finest combing wools are classified as short, and many wools of medium length are quite unsuitable for combing. *We must take a wider standard of comparison, and* try to define what is technically described as the *service* of the various wools. This can be done best by giving the averages of these qualities—(1) Length of staple, (2) Weight of fleece, (3) Yarn number, (4) Use.

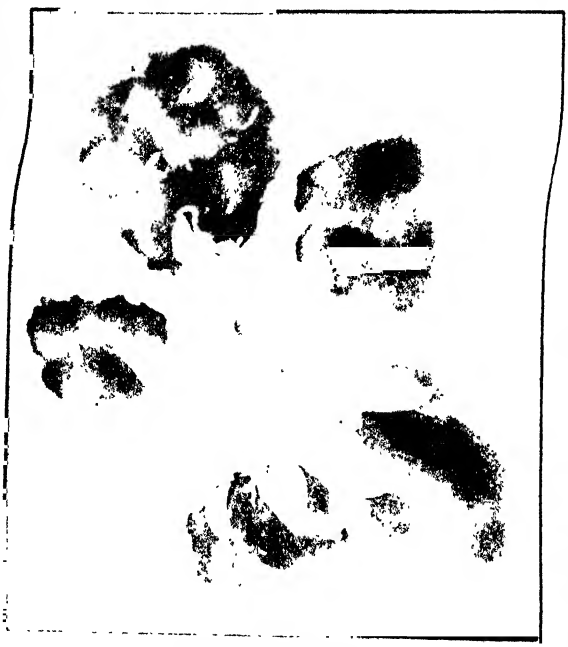
Qualities. Generally speaking, the qualities of fibre most desired are—(1) Length, (2) Fineness, (3) Soundness, (4) Colour or lustre, (5) Elasticity, (6) Softness. Fleeces are classified according to the degree in which they possess these qualities, as finest, very fine, fine, good, medium, coarse.

In the trade much confusion has arisen by the different methods of measuring the counts of yarns in various localities. When we deal with yarns, these differences will be thoroughly considered. The system coming generally into use is that upon which worsted yarns have been calculated. It is simple and easily understood. A hank is 560 yards of yarn, and the number of hanks in the pound avoirdupois gives the number of the yarn. If there are 20 hanks in the pound, the yarn is number 20; if there are 60 hanks to the pound, the yarn is number 60, or 60's. Upon this plain standard we have based our calculations.

COTTON

The Cotton Plant. Cotton fibre is derived from a plant to be found growing wild in nearly every tropical and sub-tropical country on the surface of the earth. Our globe has a cotton belt extending between the 40th parallels of latitude. Growing in many different climates and soils, the *Gossypium*, as botanists name it, has developed local peculiarities; but in every region the seeds of the plant are enveloped in a fluffy fibre, designed, it seems, to assist in protecting and disseminating the seeds. Early in his terrestrial career man appropriated this fibre, extracted the contained seeds, and used the clothing of the plant germs for the covering of his own nakedness.

Taken by itself, a cotton plant seems rather an unpromising producer of clothes. The five tufts of fibre springing from the five-celled capsule appeal *more to the sense of beauty than to the perception of utility.* But multiply the capsule a millionfold, let these capsules spread their down on the herbage around, gathering in heaps like drifts of snow, and then will be perceived the munificence of the gift which tropical nature offers man in cotton. Wherever the cotton plant grows there has been, at one time or another, a cotton industry. Historians used to tell us that cotton manufacture began in India, in Egypt, in China, or elsewhere, but we cannot affirm with certainty that cotton manufacture originated in any particular locality.



THE COTTON PLANT

The Cotton of the New World. For the root of our modern cotton industry we have to look to India, where cotton has been grown, spun, and woven from time beyond knowledge. Curiously enough, the discovery of the cotton plant growing on one of the West Indian islands confirmed Columbus in the idea that he had reached India by a western route. The great navigator was familiar with cotton, and he saw that the plant growing on the West India Islands gave a longer, finer staple than the cotton plant of East India. The Spaniards, taught centuries before the secret of cotton spinning and weaving by the Moorish invaders, sought to

utilise the resources of the continent given them by the hand of fortune, and cotton manufacture became an important industry at Valladolid and elsewhere. The ambition of Spain, however, to excel the wondrous cotton prints which her rival Portugal imported from Calicut, proved futile. Another and stronger nation, even then pushing along the path of empire, was to accomplish the task.

Not content with wresting from Spain the North American continent, the English went east, and established themselves on the vast peninsula of India. In 1600 Elizabeth granted a charter to a company of merchant adventurers which afterwards grew to imperial power, under the name of the East India Company. From the charter of "John Company," we learn that one of the principal objects of the incorporation was to trade in muslins and calicoes. How the Company rose to power, annexed territories, and formed the great Indian Empire, history records, and the stirring story has often been told; but the cotton trade of this country can hardly be described without some reference to the East India Company. It was in this industry that *the eastern and western sections of the British Empire developed rival and apparently antagonistic interests.*

The Industry of Lancashire. To many it must be a matter of wonder, if not mystery, that nearly the whole of the cotton industry of England is concentrated in the county of Lancashire. Trades tend to centralise in the particular area which affords most economic advantages. Seemingly accidental, the location of any industry generally finds explanation on economic, and sometimes on historical, grounds. For the pre-eminence of Lancashire in the cotton trade, neither the economic nor the historical reasons hold good. India manufactured cotton thousands of years before Manchester was founded, and it has the raw material at hand, while Lancashire must transport it thousands of miles. Cotton was spun and grown in Florida in 1536, while Manchester was learning to weave fustians, and now the cotton wool of Florida is spun in Lancashire, to be returned, in spite of a tariff wall, to America in the shape of cloths.

The explanation lies in the peculiar physiographic character of Lancashire. Cotton is a very delicate fibre and cannot be successfully spun under all conditions. Three special conditions the cotton spinner requires—an equable and temperate climate, a humid atmosphere, and a copious water supply. Bounded on the west by the sea, Lancashire is seldom visited by severe frosts or hard winters, while on the eastern side high hills form a watershed which provides abundance of water all the year round. The most important and most secret factor, however, is the clay sub-soil of the county. On this clay bed beneath the soil the rain-water lies, and evaporates as the temperature of the upper air rises, rendering the air moist and humid. In a warm, dry atmosphere the fibres become brittle and refuse to combine; in a wet condition cotton collapses and sticks. The medium between dampness and dryness is the ideal. The humidity of Lancashire's atmosphere has made that county the greatest cotton-spinning centre in the world.

As far back as the seventeenth century Manchester people seem to have been attracted by cotton, and the modern development of the cotton industry dates from the beginning of the eighteenth century. Up till 1735 cotton was wholly spun by hand, the primitive method practised for centuries in the lands where cotton is grown. About 1735 it occurred to a man named Wyatt that cotton might be spun by drawing it through rollers.

Introduction of Machinery. Let us explain. The raw cotton, as it came from the West Indies and Smyrna, was a mass of dirty fibres. The cotton manufacturer first opened it out and shook it free from dirt by hand, carefully picking out all the stray seeds, dirt, fragments of leaves and other vegetable matter. Next, he took two flat pieces of wood filled with spikes and drew the cotton from the one to the other, carding it out into a fine fleecy condition. Next, the cardings were fixed on a wooden tool set above a spinning-wheel. Most people have seen a spinning-wheel. The wheel, it may be explained, does not spin; its function is simply to drive the spindle on which the spun yarn is wound. The spinning agent is the hand of the spinner. A thin strand of fibre is carefully drawn off the carding and wound on the wheel-driven spool. With one hand the spinner drives the wheel, and with the other carefully twines and draws out to slender fineness the fibre. In that primitive instrument lie all the principles of cotton spinning. The greatest water-wheel in the world is simply a larger brother of the small hand wheel, and performs precisely the same office.

Wyatt's machine substituted a series of drawing rollers mechanically driven for the fingers of the spinner. The contrivance was not a great success; but it pointed the way to other inventors. Richard Hargreaves hit on a different idea for spinning and drawing out the cotton threads by mechanical means. He devised a frame, on one side of which he placed the cotton wool, and on the other the yarn bobbin, starting the two parts close together and drawing them apart, slowly and with regulated motion, thinning out the thread. This was the famous spinning Jenny, popularly ascribed to Arkwright. Hargreaves made his machine practical in 1767, and it was widely adopted by cotton manufacturers, without yielding much profit to the inventor.

Organiser of the Cotton Factory. About the same time Richard Arkwright was working at his spinning machine, developing Wyatt's idea, and in 1769 he took out a patent. To Arkwright belongs the merit of putting cotton spinning on a scientific basis. His drawing machine was contrived on definite lines, the draught being properly regulated, so that the spinner knew exactly what weight of thread he could get into a given length or *vice versâ*. The inventor calculated that if he speeded his

drawing rollers to double the number of revolutions of his delivery rollers, the yarn would be drawn out to twice the length. Similarly, if the winding apparatus ran at double the speed of the drawing rollers, the thread would be lengthened by that proportion. In 1780 Samuel Crompton, another inventor, combined the ideas of Hargreaves and Arkwright in a contrivance he named the spinning mule, and gave to cotton manufacturers the machine which, in its improved form, has enabled them to produce mechanically threads finer than the spider's web, and more regular than the most delicate products of the patient spinners of Dacca. Though his invention had not the valuable properties of Crompton's mule, Arkwright has other claims to fame in cotton manufacture. He improved the machine carder, ranged the drawing and spinning machines in regular gradation—in short, the ex-barber organised the cotton factory.

Weaving Machinery. While cotton spinning was developing by mechanical invention, the weaving process remained almost stationary. The main end of cotton spinning is cloth manufacture, and when the secondary process lags far behind the first, the loss is great both to the industry and to the consumer of the product. The first result of increasing the rapidity of cotton spinning was increase in the number of weavers employed, not only in this country, but also in India. Between 1770 and 1820 the Indian import of British cotton yarns was enormous; but in later years cotton cloths were sent instead, and the Hindu weavers died off by the thousand. In this country, about the year 1800 the cotton weaving trade employed 250,000 weavers, but the invention of the power loom took the bread out of the mouths of at least two-thirds of that number.

The power loom was invented by the Rev. John Cartwright in 1785. Cartwright was a clergyman, and became interested in weaving from a purely academic point of view. He set about inventing the power-loom to prove to some friend his contention that it could be done. The loom as first invented was quite useless; but the persevering inventor corrected his errors, and in the end produced a serviceable power-loom. For some years the introduction of the power-loom was slow; but about 1812 so many factories began to use Cartwright's invention that thousands of weavers were thrown idle, and caused riots in many Lancashire towns. The power-loom was necessary, however, to the efficiency of the cotton industry, and though we may hope that one day improvements and labour-saving inventions will be introduced in a manner involving less suffering to the workers, we must recognise the benefits which have accrued to mankind from the power-loom.

At first it seemed to everybody that the power-loom would be confined to the weaving of plain cloths; the machine could only go on repeating with blind regularity a few simple motions; pattern and fancy weaving was yet the safe preserve of the hand-loom weaver. Certain Scottish and English manufacturers, however, did not share the common opinion of the power-loom, and proceeded, early in the nineteenth century, to utilise it for the highest-class of fancy weaves, mounting the power-looms with ingenious and efficient pattern-forming appliances by automatic change of shuttle; by supplementary warps, and other contrivances, patterns of the most elaborate kind were woven, and when the jacquard apparatus came to give the warp a mobility equal to that of the weft, the circle was completed, and the power-loom became an instrument of art far surpassing the finest hand-loom.

The Thread Industry. While the English spinners were intent on bringing their yarns to the loom, the Dutch cotton manufacturers were finding another market in the production of thread for the lace workers and makers of garments. Up to the middle of the eighteenth century the Dutch had it all their own way in the thread trade; but at that time a noble lady, named Shaw, living in Renfrewshire, near Paisley, began to manufacture cotton thread, for both her own domestic use and for that of her friends. The lady of Bargerran, as she was pleased to be called, developed quite a large trade, and her near neighbours, with that commercial keenness which has since characterised the thread manufacturer, began to compete with Lady Shaw in a rather dishonest manner. Of course, there were honest thread-makers in Paisley, and the honest and dishonest between them had built up quite a respectably-sized business by the year 1789. At that time the thread trade employed over 4,000 people in Paisley alone. Having this start, the Scottish thread-makers were enabled to take advantage of every new improvement in the cotton-manufacturing process, and almost before English spinners were aware of it their northern rivals had established a practical monopoly in the thread trade. Here and there, in Lancashire and Nottingham, thread manufacturers had quietly established themselves, and gradually came into the larger markets of the world, to compete with the great Paisley concerns. For more than sixty years the commercial battle was waged. In 1896 the Paisley firms amalgamated, with a capital of £10,000,000, and as a counter-move, the English firms united under the name of the English Sewing Thread Company. But victory was with the Scots, who had already taken precautions. They held a large interest in the syndicate organised to oppose them. The English company was therefore like a besieged city with the enemy in the citadel. Terms were arranged, and the sewing-thread manufacture passed into the hands of monopoly.

Lace Making. The latest development of the cotton trade was the lace factory. One of the first European industries to make large demands for cotton yarn and to stimulate cotton spinning, lace-making was the last to submit to factory centralisation. For hundreds of years lace was made by hand. The first form of it was a kind of crochet-work, wrought by a needle, and therefore named point lace or guipure. In 1561 a Dutch lady made an

imitation lace by pinning the pattern down on a cushion, and plaiting threads over it in the form desired. This became known as pillow lace and developed on lines of its own. Lace-making is essentially an artistic home industry, and it might have remained outside the circle of machine industry but for the invention of a lace loom by a man named Hammond in 1768. The idea was taken up by Heathcote, a Nottingham hosier, who made a practical machine; Morley, founder of the great firm of Morley & Co., made further improvements, taking out patents in 1811 and 1824. In the latter year two other Nottingham firms, Lever & Turton and Clark & Mari, took out patents for improvements in the lace loom. Like the Paisley thread-makers, the Nottingham lace manufacturers were well on their way before the other members of the cotton trade had realised that a vast market had been opened up and was rapidly being monopolised. Nottingham has retained the lead it thus gained. The lace loom is like no other kind of weaving machine; the warp-beam is under the feet, and the cloth-beam over the head of the weaver; no shuttle flies across the warp, but each thread of the warp has a shuttle all to itself; the lifting leaves of the healds are absent, and instead strong fingers, directed by the jacquard apparatus, pull aside the threads of the warp; the rhythmic beat of lathe and heald and shuttle, so musical and suggestive of pleasant harmony, has given place to a louder, harsher, more powerful sound. Iron and steel and brass, the lace loom is a gigantic tool of titanic power devoted to the production of the lightest, filmiest of fabrics; the force of steam, of electricity, the strength of metal forged and moulded, the energy called into action by powers centripetal, centrifugal, and lever—all combine to create a filmy fabric of flowers and wreaths.

Cotton Trade of Europe. Before the discovery of America European cotton industry depended almost wholly on the Levant for raw material. Both demand and supply were small. With the discovery of the West Indies and America, however, a great change came. Cotton of the finest quality was to be had for the taking in those wonderful islands of the West. Spaniards, Dutch, and English shipped cotton from Cuba, Jamaica, Barbadoes, and the other West Indian Islands, in reckless greed, bringing to an industry only beginning a plethora of raw material. Thus gifted and endowed, the cotton trade of Europe took its start. The wool-spinners of Valladolid, Haarlem, Tours, Lancashire, and Yorkshire, finding a cheap spinning material at hand, entered into cotton production, and created a permanent market for cotton fibre. During the troublous sixteenth and seventeenth centuries the cotton industry, as the youngest and least important of the industrial enterprises then existing, suffered most, and grew but slowly, like a weakly child born in slumdom. Not until the English had served themselves heirs of Spain's dying empire, and taken possession of the West Indian Islands, was the cotton industry firmly established on a sure supply of raw material, and the trade enabled to grow with healthy vigour.

As the spinners of Lancashire attained pre-eminence in the trade, they began to export cotton cloths to India, competing in the bazaars with native cloths. Finding that the Western invaders could sell them manufactured cloth cheaper than they could make it, the Hindu weaver-cultivators gave up spinning and weaving, devoted themselves to cotton culture, and sold the fibre in exchange for the finished article. So another source of supply was provided for the cotton industry. Lancashire received its first consignment of Indian raw cotton in 1783, the amount being 60,000 lbs.

North American Cotton. About 1530 the Spaniards began to settle on the mainland of the American continent, founding the state which has been named Florida. While their countrymen were rendering desolate the Antilles, these settlers took a more sensible way of enriching themselves. In 1536 the colonists of Florida made their slaves raise cotton from the seed of the Barbadoes cotton plant. Following close on the heels of their rivals, the English settled in Florida, and soon dominated the colony. With characteristic energy they took up the cultivation of cotton, utilising the islands lying along the sea-board of Georgia, separated from the mainland by salt marshes. Climate and soil favoured the plantations of cotton. The product was a fibre of superior quality, longer, finer, silkier, than any cotton seen in the world before. For two hundred and fifty years the cultivation of cotton spread over the American continent, but always for home consumption.

In 1770 the colonists, hearing of the market for raw cotton springing up in England, determined to have a share. Samples of Sea-island cotton were sent over to Lancashire, but the staple was not found suitable for use, and no business resulted. After the War of Independence, the planters took some time to settle down into regular industry; but in 1790 another attempt was made on the Lancashire cotton market. This time the samples of Sea-island cotton were placed in the hands of Robert Owen, afterwards famous as a social reformer, but then known as the ablest cotton spinner in the trade, and a young man of singular honesty. Owen found that the cotton produced a yarn of fine quality, but the colour was so bad that he disposed of the yarn, for a mere trifle, to a Scottish muslin manufacturer named Craig. Within two months Mr. Craig returned to Owen, offering to buy as much of the yarn as the spinner could supply. Very much surprised, Owen made enquiry, and learned that by bleaching Craig had brought the yarn to a fine purity of colour. With his characteristic candour Owen laid the facts before his employer and the manufacturers associated with him. The effect of his report was immediate. In 1791 the importation of American cotton to this country amounted to 189,361 lbs. The American cotton trade, begun in this haphazard manner, has become one of the most important and established factors in the history of the modern world.

To be continued

Group 21
MATHEMATICS
2

COMPOUND QUANTITIES

Reduction of Compound to Simple Quantities, and of Simple to Compound Quantities. First Four Rules applied to Compound Quantities.

By HERBERT J. ALLPORT

34. We have defined a unit quantity to be a quantity with which we compare other quantities of the same kind, for the purpose of measuring their magnitude. Evidently, then, different kinds of quantities, such as money and time, must each have their own unit. But it is not always convenient to use the *same* unit, even when measuring quantities of the same kind. For instance, we speak of the distance between two towns as so many *miles*, and of a piece of string as measuring so many *inches*. It is therefore necessary to make lists, or *Tables*, showing the connection between the unit and its various multiples and subdivisions.

TABLES

35. The following tables are in general use in England at the present time.

MONEY.

The unit of English money is the pound sterling (£1)

4 farthings	= 1 penny (1*d.*)
12 pence	= 1 shilling (1*s.*)
20 shillings	= 1 pound (£1)

¼*d.*, ½*d.*, ¾*d.* are used to denote 1 farthing, 2 farthings, 3 farthings

TIME.

The unit of time is 1 day (a "mean solar day").

60 seconds (sec.)	= 1 minute (1 min.)
60 minutes	= 1 hour (1 hr.)
24 hours	= 1 day
7 days	= 1 week
365 days	= 1 year (1 yr.)
366 days	= 1 leap year

[See note on the Calendar.]

AVOIRDUPOIS WEIGHT.

For weighing common goods. The unit is the pound weight, 1 lb.

16 drams (drs.)	= 1 ounce (1 oz.)
16 ounces	= 1 pound (1 lb.)
28 pounds	= 1 quarter (1 qr.)
4 quarters	= 1 hundredweight (1 cwt.)
20 hundredweight	= 1 ton
14 pounds	= 1 stone

TROY WEIGHT.

For weighing precious metals. Troy weight is now illegal, except the ounce.

24 grains (grs.)	= 1 pennyweight (1 dwt.)
20 pennyweights	= 1 ounce (1 oz.)
12 ounces	= 1 pound (1 lb.)

APOTHECARIES' WEIGHT.

For weighing drugs.

20 grains	= 1 scruple (1 scr. or 1 ℈)
3 scruples	= 1 drachm (1 dr. or 1 ʒ)
8 drachms	= 1 ounce (1 oz. or 1 ℥)

Note: The grain Troy is the same as the grain Apothecaries': and 7000 grains = 1 lb. Avoirdupois.

LINEAR MEASURE.

The unit is the yard. 1 yd.

12 inches (ins.)	= 1 foot (1 ft.)
3 feet	= 1 yard (1 yd.)
5½ yards	= 1 pole (1 po.), rod, or perch
40 poles	= 1 furlong (1 fur.)
8 furlongs	= 1 mile (1 mi.)
3 miles	= 1 league (1 lea.)

1 chain, of 100 links = 22 yards, so that
10 chains = 1 furlong, and
80 chains, or 1760 yds. = 1 mi.

SQUARE MEASURE.

For measuring area. The unit is the square foot.

144 square inches (sq. ins.)	= 1 square foot (1 sq. ft.)
9 square feet	= 1 square yard (1 sq. yd.)
30¼ square yards	= 1 square pole (1 sq. po.)
40 square poles	= 1 rood (1 ro.)
4 roods	= 1 acre (1 ac.)
640 acres	= 1 square mile

10 square chains, or 4840 sq. yds. = 1 acre

CUBIC MEASURE.

For measuring volume, or solidity. The unit is the cubic foot.

1728 cubic inches (cu. ins.)	= 1 cubic foot (1 cu. ft.)
27 cubic feet	= 1 cubic yard (1 cu. yd.)

MEASURE OF CAPACITY

The unit is the gallon.

4 gills	= 1 pint (1 pt.)
2 pints	= 1 quart (1 qt.)
4 quarts	= 1 gallon (1 gall.)
2 gallons	= 1 peck (1 pk.)
4 pecks	= 1 bushel (1 bush.)
8 bushels	= 1 quarter (1 qr.)

36. Note on the Calendar. The mean solar day, i.e. the interval occupied by one revolution of the earth about its axis, is the unit of time. The mean tropical year, i.e. the interval between one vernal equinox and the next, is equal to 365·2422... solar days.

In the time of Julius Cæsar this number was not so accurately known. It was then considered to be 365·25 days. Thus, 4 years = 365·25 × days = (365 × 4) + 1. Hence, once in 4 years, an extra day was put in the calendar. The Roman year began in March [hence, *September*, the

seventh month, etc.), so the day was put on to the end of the year, making 29 days in February.

But, as the length of the year became more accurately known, it was seen that 1 extra day in 4 years was too much. Hence, in 1582, Pope Gregory ordered that the extra day should be omitted 3 times in 400 years.

Therefore, if the number which represents any particular year is exactly divisible by 4, that year is a leap year; except, *in those years represented by complete hundreds, such as* 1600, 1900, *etc., only those are leap years in which the number of hundreds is divisible by* 4.

For example, 1600 was leap year, since 16 is divisible by 4. 1900 was *not* leap year, since 19 is not divisible by 4.

The *object* of this arrangement is to keep the seasons of the year in the same place in the calendar. The Church required Easter to fall always in the same season.

It was not until 1752 that this *Gregorian Correction* was adopted in England. In that year eleven days were omitted from the calendar, Sept 3 to Sept 13 inclusive, being the days which should have been omitted in the years 300, 500, 600, 700, 900, 1000, 1100, 1300, 1400, 1500, 1700.

REDUCTION

37. So far, we have only dealt with *simple* quantities, *i.e.* quantities expressed in terms of a single unit, such as £33, or 27 tons. A quantity expressed in terms of more than one unit is called a *compound quantity.*

Thus £4 2s 10½d. and 5 yds. 2 ft. 8 ins. are each a compound quantity.

A compound quantity is expressed as a simple quantity, or a simple quantity is expressed as a compound quantity, by the process of Reduction.

38. Reduction of a compound to a simple quantity.

Example 1. Reduce £17 18s. 4½d. to farthings.

```
 £  s. d.
17 18 4½
20
358 s.
 12
4300 d.
   4
17202 far. Ans.
```

Explanation. From the Tables, we know 20s make £1. Therefore £17 = 17 × 20 shillings. Therefore, put the multiplier 20 under the 17. Do the multiplication, and add-in 18s at the same time. This gives 358 shillings.

Next, there are 12 pence in 1 shilling: so, multiply the 358 by 12, and add-in 4d. This gives 4300d. Finally, since there are 4 farthings in 1d., multiply 4300 by 4, and add-in 2 farthings (½d.).

Example 2. Reduce 23 po. 3 yds. 2 ft. to ins.

```
23 po. 3 yds. 2 ft.
 5½
118
 11½
129½ yds.
  3
390½ ft.
 12
4686 ins. Ans.
```

Explanation. 5½ yds. = 1 po. Multiply 23 by 5½, and add-in 3 yds. Thus: five 3's 15, and 3, 18, carry 1; five 2's 10, and 1, 11.

Next, take half of 23 (*i.e.* divide 23 by 2) and put the result under the 118, taking care to begin in the correct place—the tens' place in this case.

Add the two results, giving 129½ yds.

Now, since 3 ft. = 1 yard, multiply by 3, and add-in the 2 ft. Thus: 3 times ½ = 1½, carry 1; three 9's 27, and 1, 28, and 2, 30, carry 3; three 2's 6, and 3, 9, etc.

Similarly, since 12 inches = 1 ft., multiply the last result by 12.

EXAMPLES 3

Reduce to farthings: **1.** £904 1s. 5¾d.; **2.** £48 0s. 11¾d; **3.** £6501 18s 7d.

Reduce to halfpence: **4.** £98 14s. 2d.; **5.** £251 18s. 4½d; **6.** £1000 1s 1½d

Reduce: **7.** £42 5s 6d. to sixpences; **8.** £53 8s. 9d to threepences; **9.** £542 15s. to crowns; **10.** £58 7s 6d to halfcrowns; **11.** £1123 14s to florins. **12.** 1527 guineas to threepences

Reduce to seconds: **13.** 14 hrs. 23 min. 19 sec.; **14.** 5 dys 17 hrs 43 min; **15.** 3 wks 2 dys. 6 hrs.

Reduce to lbs: **16.** 5 tons 17 cwt. 3 qrs; **17.** 15 cwt. 2 qrs. 21 lbs; **18.** 73 tons 19 lbs.

Reduce: **19.** 1 ton 17 cwt. 2 qrs 18 lbs 14 drams to drams; **20.** 14 cwt. 97 lbs 11 oz to ounces

Reduce to inches: **21.** 3 fur. 18 po. 4 yds 9 ins.; **22.** 18 mls 6 fur. 11 po. 2 yds 2 ft; **23.** 1 fur. 187 yds 1 ft.; **24.** 3 mls 943 yds.

Reduce to sq in: **25.** 28 sq yds 8 sq. ft 84 sq in; **26.** 2 ro. 13 po. 19 sq yds. 5 sq ft

Reduce: **27.** 4 acres 1 ro. 23 sq yds. to sq. ft.; **28.** 15 ac 3127 sq yds to sq. yds.; **29.** 5 cu yds. 17 cu ft 1314 cu in. to cu. ins; **30.** 200 cu. yds. to cu ins.; **31.** 3 bush. 2 pks. 1 gall to pints; **32.** 7 qrs. 5 bush 3 pks. to galls.; **33.** 1 gall 3 qts. 1 pt. to pints; **34.** 14 qrs. 4 bush. 1 gall. to quarts.

39. Reduction of a simple quantity to a compound quantity.

Example 1. Reduce 721946 drams to tons.

```
16 { 4 ) 721946 drams.
   { 4 ) 180486 + 2  }
16 { 4 )  45121 oz. + 2 } 10 drs.
   { 4 )  11280 + 1 }
28 { 4 )   2820 lbs. } 1 oz.
   { 7 )    705       }
     4 )    100 qrs. + 5 } 20 lbs.
    20 )      5 cwt.
```

1 ton 5 cwt. 20 lbs. 1 oz. 10 drs. *Ans.*

Explanation. We know 16 drs. make 1 oz. Therefore the no. of oz. in 721946 drs. will be the no. of 16's in 721946.

Hence, divide by 16 (using *factors*). The quotient will be ozs. and the remainder (formed as in Art. 27, Ex. 1.) drams.

Similarly, we divide this quotient by 16 to find the no. of lbs., and so on.

Example 2. Reduce 9241205 sq. ins. to acres.

```
    ⎧12 ) 9241205 sq. ins.
144 ⎨12 )  770100 + 5        ⎫
     9 )    64175 sq. ft.    ⎬ 5 sq. ins.
              7130 sq. yds. 5 sq. ft.
                 4
     ⎧11 )   28520 qr.-yds.
*121 ⎨11 )    2592 + 8       ⎫
    40 )       235 sq. po. + 7 ⎬ 85/4 yds. = 21¼ yds.
     4 )         5 ro. 35 sq. pls.
1 ac. 1 ro. 35 sq. pls. 21 sq. yds. 5 sq. ft. 5 sq. in.
                                    2 sq. ft. 36 sq. in. †
1 ac. 1 ro. 35 sq. pls. 21 sq. yds. 7 sq. ft. 41 sq. in.
                                                   Ans.
```

Explanation. The principle is the same as before. But, on reaching square yards, we find a difficulty in reducing them to sq. poles, since (*) we cannot divide by 30¼. This is overcome by reducing the yards to *quarter* yds., and then dividing by the no. of *quarter*-yds. in a square pole, viz. 121. The remainder is found to be 85 quarter-yds., i.e. 21¼ sq. yds.

† The ¼ yd. is usually expressed in feet and inches, and added to the result in that form.

EXAMPLES 4

Reduce to £ *s.* *d.*: **1.** 50627 farthings; **2.** 79165 halfpence; **3.** 91647 pence; **4.** 14051 threepences; **5.** Fifty thousand farthings; **6.** A million halfpence; **7.** 5217 sixpences; **8.** 30120 halfcrowns.

Reduce to weeks, days, etc.: **9.** 92317 min.; **10.** 842508 secs.; **11.** Two million seconds.

Reduce to tons, cwts., etc.: **12.** 7924357 drs.; **13.** 435840 oz.; **14.** 37064 lbs.; **15.** 15000000 grains.

Reduce to lbs., ozs., etc., Troy: **16.** 24102 grains; **17.** 90700 grains; **18.** 42103 dwts.

Reduce: **19.** 201042 ins. to mls., fur., etc.; **20.** 142857 ft. to mls., yds., etc.; **21.** 345024 links to mls., fur., chains; **22.** 9184203 ins. to leagues, mls., fur., etc.; **23.** 15200548 sq. ins. to acres, roods, etc.; **24.** 201028463 sq. ins. to acres, yds., etc.; **25.** 428571 sq. ft. to acres, roods, etc.; **26.** 19146428 sq. yds. to sq. mls.; **27.** 7895432 cu. ins. to cu. yds.; **28.** 773014 cu. ins. to cu. yds.; **29.** 1920743 pints to bush.; **30.** 841793 galls. to qrs., bush., etc.

40. The processes of Arts. 38 and 39 are combined in such examples as the following:

Example 1. Reduce 14295 halfcrowns to guineas.

```
        14295 halfcrowns.
            5
    2 ) 71475 sixpences.
  ⎧3 ) 35737s. 6d.
21⎨7 ) 11912 + 1   ⎫
        1701 guineas + 5 ⎬ 16s.

1701 guin. 16s. 6d. Ans.
```

Explanation. Both a halfcrown and a guinea contain an exact number of sixpences. Hence, reduce the halfcrowns to sixpences, and then the sixpences to guineas.

Example 2. Reduce 3129 oz. Troy to cwts., etc.

```
         3129 oz.
           20
        62580 dwts.
           24
       250320
       125160
7000 ) 1501920 grs.
  ⎧4 ) 214 lbs. Avoir. 3920 grs.
28⎨7 )  53 + 2  ⎫
    4 )  7 qrs. + 4 ⎬ 18 lbs.
         1 cwt. 3 qrs. 18 lbs. 3920 grs. Ans.
```

Explanation. Reduce Troy weight to grains. Then, 7000 grs. = 1 lb. Avoir. ∴ divide by 7000 (short division). This gives 214 lbs. and 3920 grs. remainder. Reduce lbs. to cwt.

EXAMPLES 5

Reduce: **1.** £1000 to guineas; **2.** 297 threepences to fourpences; **3.** 3570 guineas to halfcrowns; **4.** 591 florins to halfguineas; **5.** 250 lbs. Troy to cwts.; **6.** 1460 chains to poles; **7.** 7240 guineas to crowns; **8.** 1 ton 2 cwt. to lbs., etc., Troy.

COMPOUND ADDITION

41. Compound quantities are added together as in the following examples. The method will be the same whatever system of units we may be using.

Example 1. Add together £17 4*s.* 6*d.*, £9 11*s.* 7¼*d.*, £43 18*s.* 9½*d.*, £4 1*s.* 5¾*d.*

£	*s.*	*d.*
17	4	6
9	11	7¼
43	18	9½
4	1	5¾
£74	16	4½ *Ans.*

Explanation. Write the quantities so that units of the same kind come in vertical columns.

First add the farthings.

Say 3, 4, 6 farthings = 1½*d.* Put down ½*d.*, carry 1*d.* Add the pence, including the 1*d.* carried. 6, 15, 22, 28*d.* = 2*s.* 4*d.* Put down 4*d.*, carry 2*s.* Add the shillings, adding the units' column first, then the tens': 3, 11, 12, 16, 26, 36*s.* = £1 16*s.* Put down 16*s.*, carry £1, and add the £'s as in simple addition.

Example 2. Add together 1 ton 3 cwt. 2 qrs. 17 lbs. 5 drs., 14 cwt. 19 lbs. 3 oz., and 3 tons 5 cwt. 3 qrs. 8 lbs. 14 drs.

tons	cwts.	qrs.	lbs.	oz.	drs.
1	3	2	17	0	5
	14	0	19	3	0
3	5	3	8	0	14
5	3	2	16	4	3 *Ans.*

Say, 14, 19 drs. = 1 oz. 3 drs., carry 1.
4 oz.
8, 17, 24, 34, 44 lbs. = 1 qr. 16 lbs., carry 1.
4, 6 qrs. = 1 cwt. 2 qrs., carry 1.
6, 10, 13, 23 cwt. = 1 ton 3 cwt., carry 1.
4, 5 tons.

COMPOUND SUBTRACTION

42. Compound quantities are subtracted as follows:

Example 1. From £18 4*s*. 2¼*d*. take £11 17*s*. 4½*d*.

£	*s*.	*d*.
18	4	2¼
11	17	4½
£6	6	9¾ *Ans*.

EXPLANATION. Write the smaller quantity under the larger, with units of the same kind in the same column. Then, make the lower line up to the top line, as in Art. 13.

Say, 3 far. and 2 far. = 1¼*d*., carry 1*d*.
1*d*., 5*d*., and 9*d*. = 1*s*. 2*d*., carry 1*s*.
1*s*., 8*s*., and 6*s*. = 14*s*., carry 10*s*.
10*s*., 20*s*. = £1, carry £1
£1, £2, and £6 = £8.

Thus, £6 6*s* 9¾*d*. must be added to £11 17*s*. 4½*d*. to make £18 4*s*. 2¼*d*.

43. The method of Art. 14 may be used in such examples as the following:

Example. How much will be left out of £17 9*s*. 6*d*., after paying bills of £2 14*s*. 4½*d*., £7 1*s*. 9½*d*., and £4 11*s*. 6½*d*.?

£	*s*.	*d*.
17	9	6
2	14	4½
7	1	9½
4	11	6½
£3	1	9½ *Ans*.

EXPLANATION. Write the £17 9*s*. 6*d*. first, and draw a line to separate it from the amounts written below.

Add up these latter, and make the sum up to £17 9*s*. 6*d*.

Thus, 2, 4, 6 far., and 2 far. = 2*d*., carry 2*d*.
2*d*., 8*d*., 17*d*., 21*d*., and 9*d*. = 2*s*. 6*d*., carry 2*s*.
2*s*., 3*s*., 4*s*., 8*s*., and 1*s*. = 9*s*.
10*s*., 20*s*. = £1, carry £1.
1, 5, 12, 14, and £3 = £17.

EXAMPLES 6

1. Subtract £219 17*s*. 4½*d*. from £432 4*s*. 2¼*d*.
2. What must be added to £1 19*s*. 7*d*., £4 1*s*. 3½*d*., £21 11*s*. 2¼*d*., £5 4*s*. 7¾*d*., to make the total amount to £54 9*s*. 6¾*d*.?
3. Subtract 15 cwt. 1 qr. 17 lbs. 5 oz. from 1 ton 2 qrs. 5 lbs. 4 oz.
4. Find the value of 11 guineas + 7 half-sovereigns + 3 crowns + 5 florins + 37 sixpences + 347 halfpence.
5. From 14 ac. 519 sq. yds. 7 sq. ft. take 9 ac. 1163 sq. yds. 8 sq. ft.
6. Add together 5 ac. 3 ro. 14 po. 18 yds., 16 ac. 1 ro. 28 po. 23 yds., 36 ac. 2 ro. 36 po. 19 yds., and 1 ac. 17 po.
7. Subtract 4 bush. 3 pks. 1 qt. from 7 bush. 1 gall. 1 pt.
8. Find the difference (in £ *s*. *d*.) between 79263 threepences and 65129 fourpences.

COMPOUND MULTIPLICATION

44. The sum of a given number of repetitions of a compound quantity is found by the method of [illegible] multiplication.

Example 1. Multiply £14 17*s*. 8½*d*. by 5.

£	*s*.	*d*.
14	17	8½
		5
£74	8	6½ *Ans*.

Say, 5 × 2 f. = 10 f. = 2½*d*., carry 2*d*.
5 × 8*d*. = 40*d*., and 2*d*. = 42*d*. = 3*s*. 6*d*., carry 3*s*.
5 × 7, 35, and 3, 38, put down 8, carry 3.
5 × 1, 5, and 3 = 8 (tens) = £4, carry 4.
5 × 4, 20, and 4 = 24.
5 × 1, 5, and 2 = 7.

45. If the multiplier has factors, each less than 13, and they are easily seen, proceed thus:

Example 2. Multiply £2 7*s*. 8¾*d*. by 54.

£	*s*.	*d*.
2	7	8¾
		9
21	9	6¾
		6
£128	17	4½ *Ans*

Here 9 × 6 = 54.
So first multiply by 9, as in Ex. 1 above, then multiply the product by 6.

Example 3. Multiply 4 cwt. 2 qrs. 8 lbs. by 33.

tons	cwt	qrs.	lbs
	4	2	8
			11
2	10	1	4
			3
7	10	3	12 *Ans*.

11 × 3 = 33.
Hence, 11 × 8 = 88 lbs. = 3 qrs. 4 lbs.
11 × 2 = 22, and 3, 25 qrs. = 6 cwt. 1 qr., etc.

46. If the multiplier cannot be expressed in factors less than 13, or if the factors are not readily found, the following method is used.

Example 4. Multiply £3 17*s*. 6½*d*. by 247.

£	*s*.	*d*.
3	17	6½
		10
38	15	5
		10
387	14	2
		2
775	8	4
155	1	8
27	2	9½
£957	12	9½ *Ans*.

EXPLANATION. We find 200 times the quantity, 40 times, and 7 times; then add the three results.
200 = 10 × 10 × 2; ∴ multiply by these factors, in order, giving £775 8*s*. 4*d*. Next, 40 = 10 × 4. We have already multiplied £3 17*s*. 6½*d*. by 10, so we have simply to multiply that result, viz. £38 15*s*. 5*d*. by 4, and write the product under the £775 8*s*. 4*d*. Finally, we multiply £3 17*s*. 6½*d*. by 7. The sum of these three products gives the required result.

COMPOUND DIVISION

47. In Art. 22 it was stated that division may be looked upon in either of two ways. When a quantity is to be divided into a number of equal parts, then,

(i.) if we know the number of parts, we can find the value of one part. This process is sometimes called *Partition*;

(ii.) if we know the value of one part, we can find the number of parts. This process is sometimes called *Quotition*.

The method of Partition will be understood from the following examples:

Example 1. Divide £16 11s. 5¼d. by 5.

```
  £   s.  d.
5 ) 16  11  5¼
   £3   6  3¼ Ans.
```

EXPLANATION. £16 divided by 5 gives £3 quotient, and £1 remainder. This £1 is 20s., which, with 11s. from the dividend, makes 31s. 31s. divided by 5 gives 6s. quotient, and 1s. remainder. Call this 12d., and 5d from the dividend, making 17d. Divide by 5, obtaining 3d. quotient, 2d. remainder. 2¼d. is 10 far., which, divided by 5, gives ½d.

Example 2. Divide £75 2s. 9¾d by 21.

```
      £   s  d
 3 ) 75   2  9¾
 7 ) 25   0 11   + 1 far.        )
      3  11  6¼  + 6 far × 3     ) 19 far.
   £3 11s 6¼d  + 19 far rem  Ans.
```

EXPLANATION 3 × 7 = 21.

After dividing by 3, there is 1 far. rem

Dividing this quotient by 7, we get £3 11s 6¼d and 6 far rem This means 6 far. from each of the 3 sums of £25 0s 11d Thus, the complete rem is 3 × 6 + 1 = 19 far.

Example 3 Divide £20748 19s. by 456.

```
         £    s  d.   £  s  d
456 ) 20748  19  0 ( 45 10  0½ Ans.
       2508
        228
         20
456 ) 4579 ( 10s
         19
         12
456 ) 228 ( 0d
          4
456 ) 912 ( 2f.
```

EXPLANATION. We divide £20748 by 456 exactly as in simple division (Art. 26).

There is a remainder of £228

Multiply the rem. by 20, and add in 19s. from the dividend. This gives 4579s.

Divide by 456, which gives 10s quotient and 19s. rem., i.e. 228d. 456 will not divide this, so we get 0d quotient.

Reduce the 228d to far. Then 912 far. divided by 456 gives 2f. quotient.

48. In Quotition, or the division of one quantity by another of the same kind, we first reduce the quantities to the same unit, and then proceed as in simple division

Example 1. £120 4s. 5½d is divided equally amongst a certain number of persons. If each of them gets £5 4s. 6½d. how many persons are there?

```
 £  s.  d.      £   s.  d.
 5  4   6½     120  4   5½
20              20
104s.          2404s.
 12              12
1254d.         28853d.
  2               2
2509 halfp.   57707 halfp.

2509 ) 57707 ( 23 persons Ans.
        7527
```

Here, we reduce each amount to halfpence.

The quotient of 57707 by 2509 is 23. ∴ there are 23 persons.

Example 2. How many times can 1 ton 4 cwt 22 lbs. be subtracted from 6 tons 12 cwt. 1 qr 18 lbs.? How many cwts., etc. will remain?

```
ton  cwt.  lbs.      tons  cwt.  qr.  lbs.
 1    4     22         6    12    1    18
20                    20
24 cwt.              132 cwt.
112                    4
470                  529 qrs.
224                   28
2710 lbs.            4250
                    1058
                    14830 lbs.

      2710 ) 14830 ( 5 times
   28 ( 4 )  1280 lbs. rem.
      ( 7 )   320
       4 )     45  qrs. 20 lbs.
               11  cwt. 1 qr. 20 lbs.
```

Here, reduce each to lbs. After the division we find 5 for quotient and 1280 lbs. remainder. This remainder is reduced to cwts. by method of Art. 39.

Thus the complete answer is that the subtraction can be done 5 times, and 11 cwt. 1 qr. 20 lbs. remains.

EXAMPLES 7

1. Multiply 5 mls. 6 fur. 54 yds. by 48.
2. Divide 184 tons 14 cwts. 3 qrs. 16 lbs. 13 oz. by 37.
3. Multiply £53 18s. 9½d. by 3042.
4. Divide £1946 13s. 11d. by 121, using factors.
5. Divide £1057 19s. 8d. by £3 9s. 7¼d.
6. How many halfcrowns will remain after £2 14s. 7d. is subtracted as often as possible from £87 19s. 2d.?
7. Divide £53 15s. 10d. among 10 men, giving 3 of them 10s. each more than the others. [Note: Subtract the extra 30s. from £53 15s. 10d. and divide the remainder equally among the ten men.]
8. Divide £11 9s. 6d. among 7 men, giving 2 of them twice as much each as the others get each.
9. A bat and ball together cost one guinea. If the bat cost 5 times as much as the ball, find the cost of each.
10. A woman bought 12 dozen eggs. If they had cost 3d. a dozen less, she could have bought 2 dozen more for the same money. What was the original price per dozen?
11. Coffee is bought at £6 10s. per cwt. and sold at 1s. 7d. per lb. How much is gained on 1 cwt.?
12. A packet containing 5 cigarettes and a coupon is sold for a penny; another packet is given for 5 coupons. How many cigarettes should be sold for a shilling?
13. Divide £29 15s. into an equal number of sovereigns, half-sovereigns, crowns, half-crowns, shillings, and sixpences.

CORRECTION. In last line but one of division 2, page 89, read number for *figures.*

To be continued

Group 20

MATERIALS & STRUCTURES

2

CHARACTERISTICS OF IRON & STEEL

Iron in its modifications as Wrought Iron, Steel, and Cast Iron. A Short Introduction to the Fuller Course on Iron and Steel.

By Professor HENRY ADAMS

IRON [*Ferrum*; Symbol Fe, atomic weight 56] is a widely diffused metal known under three principal modifications as wrought iron, steel, and cast iron, each having very different properties primarily depending upon the amount of carbon (symbol C, atomic weight 12) entering into its composition. Briefly, wrought iron with very little carbon is fibrous, tough, soft, and ductile; may be forged, hammered, or rolled to various shapes. Steel, with more carbon, varies from fibrous to crystalline. When containing a small amount of carbon, it may be welded, and with more carbon may be cast. It can be forged and tempered, and is very tough and strong. Cast iron, containing the most carbon, is crystalline and brittle, fluid at high temperatures, and takes complicated shapes by casting in a mould.

Figure 28 gives a pictorial representation of the effect of carbon in iron. The block shown may be supposed to be formed of an infinite number of layers, the lowest being pure iron and the highest iron with as much carbon as it will hold. The black wedge shows the amount of carbon in the various layers if it could all be collected at one end.

Distinguishing Features. Workmen often require to distinguish these different modifications. Generally the shape and external appearance are sufficient to indicate the material, but there are precise tests. For instance, if made red hot, cast iron or malleable cast iron will fly to pieces when hammered. If plunged into water when red hot, steel will harden, while wrought iron will remain soft. They can also be distinguished very readily by the appearance of a fractured surface: wrought iron has a dull bluish fibrous fracture, with sometimes a small crystalline portion; mild steel has a silky appearance; while cast iron has a fine granular fracture generally on a dull grey colour. Cast steel has rather a more silvery fracture than cast iron, with very fine grain when of the best quality, as in tool steel. It is perhaps more difficult to distinguish between wrought iron and mild steel, particularly in work finished bright, but a drop of nitric acid will not produce any change upon wrought iron, while upon steel the colour of the spot will vary from brown to black according to the amount of carbon present, the reason being that the iron dissolves and leaves the carbon as a black deposit.

The following table by Bauerman shows very concisely the effect of carbon in iron:

Name.	Percentage of Carbon.	Properties.
Malleable iron	0·25	Is not sensibly hardened by sudden cooling.
Steely iron	0·35	Can be slightly hardened by quenching.
Steel	0·50	Gives sparks with a flint when hardened.
"	1·00 to 1·50	Limits for steel of maximum hardness and tenacity.
"	1·75	Superior limit of welding steel.
"	1·80	Very hard cast steel, forging with great difficulty.
"	1·90	Not malleable hot
Cast iron	2·00	Lower limits of cast iron, cannot be hammered
" "	6·00	Highest carburetted compound obtainable

Iron Ore. Iron is obtained by smelting various ores which are more or less rich in the metal. These ores may be classified as follows:

Oxides.—Magnetic Oxide, or Magnetite—from Sweden, Norway, North America, etc.

Red Hæmatite, or *Kidney Ore*—from Whitehaven and Ulverston. *Specular Iron Ore* is of the same composition, but of crystallised masses, and is found in Russia, Spain, Elba, etc.

Brown Hæmatite—differs from Red Hæmatite in containing water, and it is found at Forest of Dean, Alston Moor, Northamptonshire.

Carbonates.—Spathose Iron Ore, Spathic Ore, or Iron Glance—from Northumberland and Durham.

Argillaceous—Clay Ironstone or Clay Band—from South Wales, Dudley, North Staffordshire, Yorkshire, etc. Black Band Ironstone—from Ayrshire and Lanark, containing coaly impurities.

The Blast Furnace. Fortunately the coal measures occur close to the beds of ore, so that the fuel is on the spot and the cost of carriage is minimum. The hæmatite ores are nearly pure oxides, and they may be put direct into the blast furnace for producing the molten metal, but the other ores have to undergo a preliminary process of roasting. This consists of breaking the ore into pieces of convenient size, mixing it with coal in large heaps and allowing them to burn slowly so as to drive off the contained water, carbonic acid gas and sulphur. Or the ores may be roasted in a common kiln something like a lime kiln, or in a special form known as Gjers roasting kiln. The operation is known as calcining or roasting. The subsequent operation is as follows: the roasted ore, with earthy matter to form a flux, and fresh fuel to maintain heat, are smelted together in a blast furnace [29] from 50 to 100 feet high, to obtain the metal from the ore.

The blast furnaces are frequently in pairs, with a hoist between each pair for lifting the ore and fuel. The charge depends upon the par-

ticular kind of ore, but consists of, say, 5 cwt. of ore, 2 cwt. of limestone, and 5 cwt. of coke, repeated every half hour, the furnace being kept full.

In connection with the blast furnace is a large bed of moulding sand called a pig-bed, in which impressions are made by ramming the sand round wooden blocks three, four, or six feet long. Several rows of these impressions are made, and are connected by channels for conveying the molten metal from the blast furnace as in 30. The molten metal is run off every twelve hours, and when cool is broken up, the channels forming what are called *sows* and the separate impressions *pigs*.

The chemical action of the blast furnace is as follows: the silica, alumina, and iron in the ore and flux combine, by the aid of heat, to form a glassy slag, which floats on the molten metal and runs off near the bottom of the furnace, but at a higher point than the molten metal, which, being heavier, flows from the bottom. A small portion of the carbon in the fuel combines with the iron and keeps it fluid until it is drawn off at the tap hole. The remainder of the carbon of the fuel combines with the oxygen in the ore and the blast to form carbonic oxide or carbon monoxide (CO), carbonic acid or carbon dioxide (CO_2), etc., which pass out at the top, or are conveyed away to be used for raising steam by combustion under steam boilers. The reactions are shown in 31. Carbonic oxide is the gas dreaded in fiery mines and known as fire-damp. It causes explosions, burning with a blue flame. Carbonic acid is the fatal gas known as choke-damp, which is produced by the combustion of carbonic oxide and is the result of the explosions.

Classes of Pig Iron. Pig iron is classified under three main heads: *Bessemer iron*, *Foundry iron*, and *Forge iron*. Bessemer iron is made from hæmatite ores and used for conversion into steel on account of its freedom from impurities. Foundry iron is the name given to all pig iron having a grey fracture and large proportion of combined carbon; it is produced under a high temperature and full supply of fuel. This again is subdivided into three or six classes according to the ratio between the carbon chemically combined and that mechanically mixed.

Forge iron consists of white pig iron, almost free from uncombined carbon and suitable for conversion into wrought iron. It is produced with a low temperature or insufficient supply of fuel, and is frequently run from the blast furnace into iron moulds, rendering it brittle for ease in breaking up.

The foundry iron goes direct to the foundry, where the different qualities are mixed in various proportions according to the nature of the casting for which the metal is required.

The forge iron has to undergo other processes before the finished wrought iron is produced. The first process is refining, which is both a chemical and mechanical operation. This consists of melting the pig iron with coke or charcoal in an open hearth or refinery furnace [32] supplied with an air blast so as to impinge on the melted metal and furnish an oxidising atmosphere. This carries off a portion of the carbon, and at the same time removes a portion of the impurities in the form of slag. The melted metal is then poured into a cast iron trough lined with loam, kept cold by water circulating below, and the sudden chilling has the effect of causing the whole of the carbon to remain in chemical combination producing a hard silvery-white fracture. By this change the fluidity of the iron is reduced and the subsequent puddling process is facilitated. For common wrought iron the forge pig may go direct to the puddling furnace without undergoing the intermediate refining.

Puddling. There are two methods of puddling, called respectively dry puddling and wet puddling. Dry puddling is the process of obtaining wrought iron by burning the carbon out of refined cast iron in a reverberatory furnace [32]. The oxygen of the air, at the high temperature employed, combines with the carbon to form carbonic oxide gas which escapes, and with the silicon and other impurities which run off as slag. In hand-puddling the mass is stirred about until it is of sufficient tenacity to be lifted out of the furnace in balls or blooms of 60 to 80 lbs. each; a 5 cwt. charge takes about two hours to work off.

In Danks' rotary furnace the revolution of the furnace effects the same as hand labour. If the operation be stopped before the carbon is all removed, puddled steel is obtained. Wet puddling, or "pig-boiling," is the more modern process, in which grey unrefined pig-iron is converted direct. The bed of the reverberatory furnace is lined with broken slag, cinder, scale, etc., fused together, and over these a fettling of soft red hæmatite or *puddlers' mine* is placed.

The stages of the puddling process are—

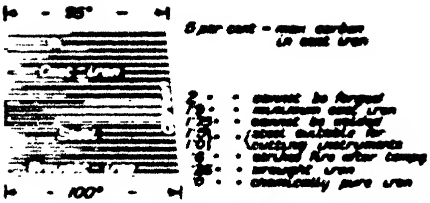
(1) Graphitic carbon converted into combined carbon, and silicon partly oxidised by roasting and melting.

(2) Metal drawn from the sides, and mixed with that in the centre.

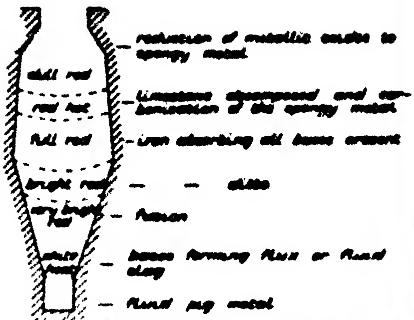
(3) Metal *boiled* for twenty minutes, impurities being oxidised by agitation of the mass.

(4) Pasty metal *balled* and re-balled ready for shingling.

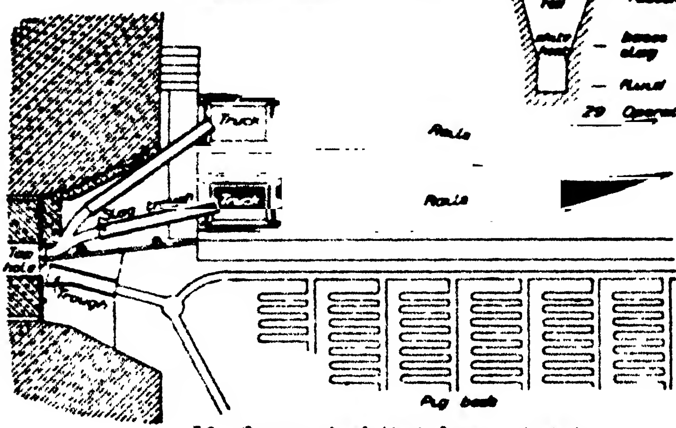
After removal from the puddling furnace, at a welding heat, the blooms are put under a heavy trip hammer, a rotary squeezer, or a hydraulic press, to remove the slag and impurities from the spongy mass, and to solidify the metal. They are then passed through chilled rolls, flat or grooved, of various dimensions, to produce the shape required, being drawn down gradually to the finished size. After passing the bloom through the first series of rolls, it is known as puddled bar. These puddled bars are then cropped, piled, re-heated, welded, and rolled to form merchant bar. The material being again put through these processes becomes single, double, or treble best according to the number of repetitions. Cold rolling improves the tenacity and raises the limit of elasticity of wrought iron in a remarkable degree, but the ductility is somewhat diminished. It leaves the iron with a



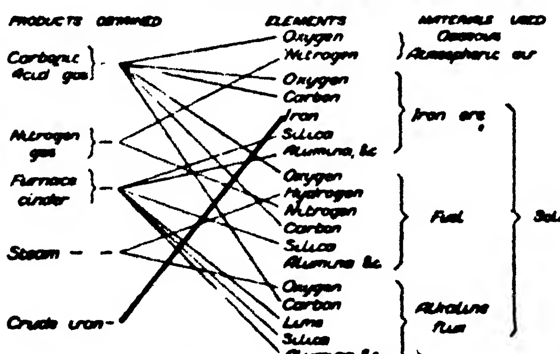
28 Graduated composition of iron and steel



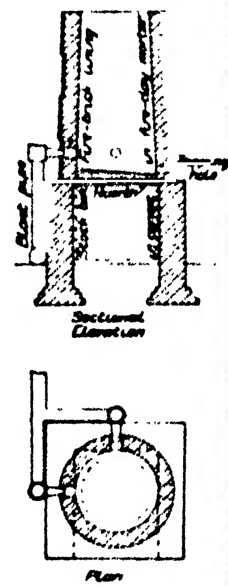
29 Operation of blast furnace



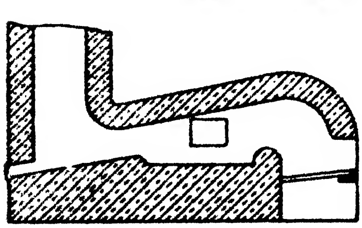
30 Arrangement of blast furnace pig beds



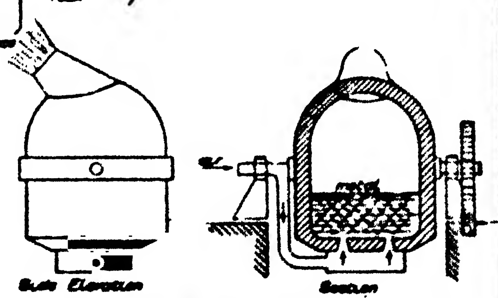
31 Reactions in blast furnace



33 Cupola



32. furnace for melting, refining, puddling, etc.



34. Bessemer converter

35. Butt weld

36. Scarf weld

37. Vee weld

smooth, bright surface, free from the scale of black oxide which is left by hot rolling, and as it can be rolled exactly to gauge, there are many purposes for which it requires no further preparation.

Defects. There are two chief defects to which wrought iron is liable—cold-shortness and red-shortness. Cold-shortness is produced by the presence of phosphorus as an impurity; the iron is brittle when cold, but of ordinary character when heated; it cracks if bent cold but may be forged and welded at high temperatures. Red shortness is generally produced by the presence of sulphur, sometimes by arsenic, copper, and other impurities; the iron is tough when cold, but cannot be welded, and is difficult to forge at high temperatures.

Some parts of machinery require a hard wearing surface and a tough interior; the iron is then *case-hardened*. The piece is generally finished bright and then heated to a cherry red and placed in contact with broken prussiate of potash (K_4FeCy_6), scraps of leather, or other nitrogenous substances. The surface is thus converted into steel by the absorption of carbon and is hardened by quenching in water.

Steels. Steel may be made by the addition of carbon to wrought iron or the abstraction of carbon from cast iron; both methods are in use commercially, but the old classification by which the percentage of carbon alone determined the designation is now discarded, as some steel may have only the same amount of carbon as some wrought iron. It is the mode of manufacture which really determines the classification.

Blister steel is produced by a process called cementation. Bars of purest wrought iron are placed in a furnace between layers of charcoal powder, and kept at a high temperature (say, 1400° F.) for from five to fourteen days; the bars are now brittle, crystalline and more or less covered with blisters. This material is used for facing hammers, etc., but not for edge tools, and is largely used for conversion into other kinds of steel. *Spring steel* is blister steel heated to an orange red colour and rolled or hammered. *Shear steel* is blister steel cut into short lengths, piled into faggots, sprinkled with sand and borax to form a flux, and placed at welding heat under a tilt hammer. Single and double shear steel denotes the number of times the process is repeated. It is used for large knives, scythes, plane irons, shears, etc., frequently in conjunction with iron.

Bessemer steel is made from grey pig iron containing a large proportion of free carbon, a small quantity of silicon and manganese, but free from sulphur and phosphorus. The iron is melted in a cupola [33], somewhat similar to a small blast furnace, and run into a converter lined with fire-brick and suspended on hollow trunnions [34]. Air is blown through the metal for about twenty minutes to remove all the carbon; five to ten per cent. of spiegeleisen is then added, and blowing is resumed long enough to incorporate the two metals. The converter is then partly rotated and the molten metal poured out into a large ladle which is carried by a crane round a series of moulds into which the metal is poured to form ingots. The ingots, when cold, being porous, are reheated and put under a steam hammer, then rolled or worked as required.

Bessemer steel is used for rails, tyres, rolled joists, common cutlery and tools, roofs, bridges, etc. *Gilchrist-Thomas*, or *basic* steel, is similar to Bessemer, but there is a difference in the lining of the converter, which is basic, or non-siliceous, made from burnt dolomite or magnesian limestone. By this process the phosphorus is quickly and cheaply eliminated by combining with the lime, and inferior iron may consequently be employed.

Siemens' Steels. A very ductile steel is produced by the various open-hearth Siemens' processes, the principal of which is perhaps the Landore Siemens steel. The iron ore is treated in a rotary furnace with carbonaceous material and converted into balls of malleable iron, which are transferred direct to the steel melting furnace, where spiegeleisen is added. The result is steel of a very ductile quality, dense and uniform in texture, and by a careful proportioning of the materials any required degree of toughness and hardness may be obtained. Structural steel may be divided into three grades: *mild* or *soft* below 0·15 per cent. of carbon content and suitable for boiler plates and similar uses; *medium*, 0·15 to 0·30 per cent. of carbon, for joists and general structural purposes; *hard*, above 0·30 per cent. of carbon, for axles and shafts, etc., where wearing surfaces are desired.

Compressed steel is made by the application of pressure to the fluid metal, and the resulting steel is of superior density and tenacity, besides being free from blow holes.

Crucible Cast Steel. Crucible cast steel was originally made by melting fragments of blister steel in covered fireclay crucibles and running into iron moulds. It is now generally made direct from Swedish bars cut up and placed in crucibles with a small quantity of charcoal and the subsequent addition of spiegeleisen, or oxide of manganese. It may be forged at a low cherry red, but is unweldable; the fracture is grey and the crystals very minute. It is used for tool steel, and there are many varieties produced by slight differences in the ingredients, such as Heath's and Mushet's steels, Tungsten steel, Chrome steel, Harveyised steel, Nickel steel, and various high speed tool steels.

Dannemora cast steel may be taken as typical, the properties according to the amount of carbon being shown in the following table:

Carbon	Temper.	Tools suitable for.	Remarks.
$1\frac{1}{2}$	Razor	Turning, planing, drills, etc.	Great skill required in forging. Overheating will spoil.
$1\frac{1}{4}$	Turning Tool	Turning, planing and slotting tools, drills, small cutters and taps.	Not weldable.

No.	Temper.	Tools suitable for.	Remarks.
[illegible]	Punch	Mill picks, circular cutters, taps, rimers, small shear-blades, large turning tools and drills, punches and screwing dies.	May be welded with great care.
[illegible]	Chisel	Cold chisels, hot setts, medium size shear-blades, large punches, large taps, miners' drills for granite	Will weld with care
[illegible]	Sett	Cold setts, minting dies, large shear-blades, miners' drills; smiths' tools, as sett hammers, swages, flatteners, fullers, etc.	Will weld without difficulty.
[illegible]	Die	Boiler cups, snaps, hammers, stamping and pressing dies, welding steel for plane-irons, etc.	Will weld like iron

New varieties of steel besides those named are introduced from time to time, particularly for use in the construction of armour plates, but the reputation with which they start is not always maintained.

Cast Irons. Reverting to cast iron for foundry use, there are three usual divisions.

No. 1. *Grey.* This is soft and deficient in strength, very fluid when melted and used for ordinary castings; it contains from 0·6 to 1·5 per cent. of carbon chemically combined, and 2·9 to 3·7 per cent. mechanically combined.

No. 2. *Mottled.* This is of variable hardness and takes its name from its appearance; it is stronger than No. 1, and is used for larger castings; it has more carbon chemically combined and less mechanically.

No. 3. *White.* This is very hard, strong, and fusible, containing three to five per cent. of carbon all chemically combined. It is of more use for conversion into wrought iron than for foundry purposes; but all three varieties may be mixed in various proportions for different purposes. Grey cast iron gets stronger when remelted, partly by the burning out of some of the carbon and partly by the greater proportion which becomes chemically combined. Castings that have to be machined are more easily worked when of grey metal, but a certain proportion of No. 2 has generally to be introduced to secure the requisite strength.

Chilled Cast Iron. For certain purposes a very hard face is required, as on the tread of cast iron wheels, rolls for rolling mills, and points of Palliser shells, etc. This is obtained by running the metal into a mould of white or hard cast iron for the part requiring to be chilled, protected by a wash of loam, when the sudden cooling causes a chemical combination of the molten iron and carbon. The fracture is always silvery and the direction of the crystallisation strongly marked.

Malleable Cast Iron. Malleable cast iron is made by heating ordinary castings, preferably of white cast iron, from two to forty hours according to size, in contact with oxide of iron or powdered red hæmatite, which causes a partial conversion into wrought iron by the abstraction of carbon, and a consequent change from the brittleness of a casting to the toughness of common wrought iron; it is used for cheap spanners and work of that kind. Malleable cast iron is rather a misnomer, as the material can neither be forged nor welded.

Another mode of toughening cast iron is to melt with it from one-fourth to one-seventh of its weight of wrought iron scrap; some of the carbon in the cast iron unites with the wrought iron, and the mixture, having a smaller percentage of carbon as a whole, forms an approximation to steel. Although wrought iron in the ordinary way cannot be melted, but only becomes a pasty mass when heated, the addition of a minute quantity of aluminium, by Nordenfelt's *Mitis* process, enables it to melt and flow sufficiently to form castings having all the properties of wrought iron, except that they are perfectly homogeneous and free from stratification; Mitis metal will both weld and harden.

Metallography or Micro-metallurgy. The use of the microscope in connection with the structure of a chilled casting was first mentioned by Réaumur in 1722. In 1833 François followed with the microscope the successive steps in the reduction of iron from its ores. In 1864 Dr. Sorby, studying polished and etched specimens of iron and steel, said "steel must be regarded as an artificial crystallised rock, and to get a complete knowledge of it, must be regarded as such." About 1870 the writer recommended a study of the crystallisation of metals to an inquirer for subjects for original microscopical research in the *English Mechanic*, but the subject was not taken up practically until about 25 years later, when several investigators entered the field. From 1885 onwards many workers have been investigating the same subject, extending their labours to the micro structure of various alloys.

Forging, welding, and tempering are so intimately connected with wrought iron and steel that a brief description of these processes will be of some interest.

Forging. Wrought iron at a red heat may be hammered into various shapes called *forging*. When a piece is drawn down smaller, the process is called *swaging*, and when *jumped up* or hammered on the end to increase the thickness it is called *upsetting*. The more working the iron has undergone the more suitable it is for forging; common iron is not suitable, as the scale or slag in it causes it to crack. When the forging does not involve much alteration of shape, double-best may be used, but where flanging is required, as in boiler work, it is necessary to use treble-best.

Yorkshire iron is more ductile and malleable than any other, and is therefore used for important flanging or difficult forgings. For light and complicated work, such as boat hooks, charcoal iron is used. Mild steel may be forged, but it is necessary to proceed by easy stages, and it is of the utmost importance not to continue the work when the steel has reached a blue heat, or it will require annealing to remove the internal stresses that are caused.

Stamping between Dies is a modern method for making articles in wrought iron and mild steel, under the steam hammer (called drop forging) or in a hydraulic press (called pressing). The material is brought to forging heat and pressed in a single pair of dies or a graduated series, according to the amount of working it has to undergo. Spanners, draw-bar hooks, crane-hooks, steel chain, pans and dishes, elevator buckets, wheel barrow trays, and numberless articles of all kinds are thus manufactured.

Welding. Welding is the process of joining two pieces of wrought iron or steel by heating and hammering them together. To weld iron the pieces must be brought to a white heat, just scintillating, and the scale of black oxide must be swept off before they are put together. Steel requires a much lower heat, and the surfaces should be sprinkled with sand, borax, or silicate of soda, to protect them from oxidation and to aid the surface fusion. The welding temperature of steel depends upon the amount of carbon contained: hence the extra difficulty of welding two pieces of different composition. The average loss of strength in a weld is from 15 to 20 per cent., but the weld is often assisted by scarfing the two pieces together. There are three forms of welding applicable to a bar, the butt weld [35], the scarf weld [36], and the lock, vee, or grip weld [37]. The ends are first upset so as to allow of sufficient reduction in the hammering to make the weld solid without reducing the diameter below the normal size, then shaped as shown, brought to welding heat, and completed by hammering between hollow swages.

One form of welding consists in passing an electric current through the pieces to be joined. The ends are rounded so that they touch in the centre first, and the small area of contact offers great resistance to the passage of the current, which is thereby transformed into heat and surface fusion commences immediately. As the junction commences in the centre and proceeds uniformly to the outside, it is very efficient, and the weld is said to be of equal strength with the solid material, but unless great care is taken there may be a loss of 5 to 10 per cent.

Thermit welding is another form. Thermit is a mixture of aluminium and oxide of iron in fine grain and in chemical proportion. It can be ignited by a powder formed of finely divided peroxide of barium and aluminium, which may be lighted by a match. The thermit when fused has a temperature of about 5000 degrees Fahrenheit, and a little poured upon rail ends to be welded, confined in a suitable mould or case, quickly raises them to welding heat and pressure completes the joint.

Face Welding, equivalent to veneering, may also be accomplished by the hot rolling of clean metal ingots, of similar or different kinds, having a thin sheet of aluminium interposed. Thus a compound sheet of iron and copper may be produced in this way with any relative thickness of the two external metals.

Tempering. When steel is heated to a cherry red and suddenly cooled in water or oil it is rendered very hard. The exact change produced is not known, but it is supposed by some that the carbon is caused to take the crystalline or diamond form. This is the first part of the operation. If it is a tool that is being tempered, the end only is dipped in water and then brightened with a piece of grindstone, and watched until the heat travels down from the unquenched portion and causes a film of oxide to show on the brightened surface. When this reaches the desired colour the tool is plunged into water, and the hardness is found to be *let down* to the *temper* required. The following table of the colours corresponding to temperature will be found useful.

	Degrees Fahrenheit.
Lowest red heat visible in the dark ..	635
Faint red	960
Dull red	1290
Brilliant red	1470
Cherry red	1650
Bright cherry red	1830
Orange	2010
Bright orange	2190
White heat	2370
Bright white heat	2550
Dazzling white heat	2730
Welding or scintillating heat	2800

The colours at which the various tools are tempered will be found in the following table:

Colour of Film.	Temp. Fahr	Nature of Tool.
Very pale yellow straw	430	Lancets and turning tools for cast iron.
Shade of darker yellow	450	Razors and ditto.
Golden yellow	470	Penknives, turning-tools for iron.
Orange yellow	490	Cold chisels, drills, screw taps, wood tools.
Brownish yellow	500	Hatchets, plane-irons, chipping-chisels, saws for iron, tools for working granite, turning tools for brass.
Brown tinged with purple ...	520	
Light purple ...	530	Swords, ordinary springs, tools for cutting sandstone.
Full purple ...	550	
Full blue ...	570	Small saws, watch-springs, augurs.
Grey blue ...	600	Large saws, pit and hand saws.
Pale blue with tinge of green	630	Too soft for steel instruments.
Grey	750	

Tempering may be done in a bath of molten metal. Different proportions of lead and tin become fusible at temperatures varying from about 400 to 620 degrees Fahrenheit, and thus provide any requisite temperature between those limits. Watchmakers' drills and such small articles are sometimes tempered by making them red hot and thrusting them into a tallow candle. Some tool-makers have their own recipes, salt water, vinegar and water, urine, etc., being among the number.

To be continued

Group 6
CHEMISTRY
2

HOW SCIENCE MAY TRANSFORM THE WORLD

The Remarkable Advance of Chemistry in Our Own Time and the Wonderful Secrets it may Hold for the Future

By Dr. SALEEBY

AT the present day chemistry is one of the most flourishing of all the sciences. Certainly none other, save medical science, can claim such a number of earnest students. Many large manufacturing firms in Germany think nothing of employing some *hundreds* of trained chemists in order to prosecute research in the interests of the house.

Hence it is that during recent years chemistry has made remarkable advances. It is not desirable here to anticipate the discussion of these, but it is the present purpose to indicate, as far as may be, the prospects of chemistry.

For convenience we may consider, first, the future of chemical practice, and then the future of chemical theory.

The Elements. Only a few years ago it might have been said that chemistry had no new elements to discover—save perhaps one or two elements in the stars or the sun, which were supposed to be unrepresented on the earth. But the prophecy would have been wrong, for the introduction of new methods has lately enabled Sir William Ramsay to discover not merely argon, but also some five or six new elementary gases, which occur in minute quantities in the atmosphere. Nevertheless, it is probable that only very few and very unimportant elements still remain undetected. The revelation of radium will probably prove to have been the last important discovery in this direction.

Nor is practical chemistry likely to witness any striking discoveries in new compounds in what is called *inorganic chemistry*, the chemistry which mainly deals with compounds that contain no carbon. Lately Dr. Marshall, of Edinburgh, has discovered the compounds known as the persulphates, but these are of small importance, and there are probably not many more to follow.

Synthesis. But the future of practical chemistry will be mainly concerned with the artificial production of complex compounds, containing carbon. Large treatises have already been written that are concerned solely with the artificial manufacture by *synthesis* (putting together) of products which have hitherto been obtainable only through the agency of the living animal or plant. This *chemical synthesis of vital products* will occupy a very important place in the chemistry of the future. Already the chemist can build up from the elements such complex substances as camphor, vanilla, alcohol, some sugars, and even the simplest forms of what is called albumin—best represented by white of egg. Even when these "vital products" cannot be built up from their elements, they may be obtained from coal tar. The chemistry of coal-tar will play a large part in the future of chemical science.

If we were to express the difference between the past and the future of chemistry in the shortest form, it would be said that past chemistry has been almost exclusively *analytic*—analysis being the process of breaking anything down into its constituent elements—and that, this process having now been carried practically to its natural limits, present and future chemistry are concerned with the opposite process of *synthesis*. Analytical chemistry is almost a perfect science; synthetic chemistry—the father of which, M. Berthelot, is alive to-day—is still in its infancy.

The Field of Synthetic Chemistry. But we must not imagine that synthetic chemistry is or will be concerned merely with the artificial building up of compounds already known to be produced by the living animal or vegetable organism. On the contrary, synthetic chemistry has already produced, and is daily producing, an illimitable series of new compounds which are absolutely unknown in Nature. The manufacture of these compounds is of some interest to the theorist, of course, for the theorist can afford to ignore no fact; but it is chiefly pursued for practical ends. Of these the least important is the service of the dyeing industry by the production of dyes superior to any that can be obtained from the vegetable world. But the most important end, and that which individually, perhaps, occupies the majority of these investigators, is the service of medicine.

Indeed, contemporary chemistry goes far to vindicate the teaching of Paracelsus, that "The true use of chemistry is not to make gold, but to prepare medicines." Not so long ago the study of *Materia Medica*, or "medical materials" (to translate very loosely), was practically a department of applied botany. But anyone who cares to compare the text-books on this subject written a generation ago with those now being published, will find that a most astonishing change has come over the treatment. The vegetable world is being slowly excluded from such text-books, and it is hard to say where the process will end. Perhaps the majority of the drugs on which the modern physician now relies were unheard of thirty years ago. Indeed, they did not exist. They have, most of them, been manufactured, for the first time in the history of things, in German laboratories. Amongst them are included drugs which are now in universal use, and invaluable to the physician. After chloroform and carbolic acid come a host of drugs which relieve pain, stimulate various

organs, procure sleep, and so forth. But physicians have not yet obtained the ideal anæsthetic, or the ideal hypnotic, or the ideal antiseptic. With these, and with many more, the chemistry of the future will be able to supply them.

The Solver of World Problems. Again, the chemistry of the future will be of incalculable importance in solving some of the most difficult problems that confront humanity. Of these there are not a few that might be named. At present, for instance, mankind is living on its capital of coal: it is to chemistry that we must turn for a new fuel when the coalfields are exhausted. But by far the most important problem which the chemistry of the future will have to solve—and doubtless will solve—is the problem known as the "fixation of the atmospheric nitrogen." The reader is already aware of the abundance of nitrogen in the atmosphere. Now this element is an essential part of the food of man and of the food of the plant—upon which, in the last resort, man lives. But plants cannot absorb nitrogen directly from the air any more than we can, though four-fifths of every breath we draw consists of this gas. The wheat plant and man cannot *fix* the atmospheric nitrogen. Man cannot even utilise nitrogen when it is presented to him in the form of its simple compounds. He can utilise it only when it has been "worked up" by the plant into those exceedingly complex compounds which we call the albumins or proteids. Now the plant *can* utilise the nitrogen which is presented to it in the simple compounds, later to be studied, which are called nitrates. The only exceptions to the rule that a plant can take in its nitrogen only as nitrates are furnished by a few plants of the order called Leguminosæ, whose roots are lived upon by certain "nitrifying bacteria," which can take in the free nitrogen of the "soil air" and hand it on to the plant. Hence the constant supply of nitrates is necessary for the growth of the corn of the world; and at present we are rapidly using up the store of nitrates, which mainly occur in South America. When there is no more nitrate to be obtained we shall be in a sorry plight. But it may quite reasonably be expected that, ere then, chemistry will have learnt how to fix the atmospheric nitrogen easily, cheaply, and in the enormous quantities that will be required. Already the fixation can be accomplished by the use of electricity, but only in very small quantities and at a prohibitive cost.

In the World's Food Supply. Many other problems connected with the future food supply of the world's population—which is increasing in numbers at an enormous rate—will be solved by the chemistry of the future. Doubtless we shall learn, for instance, to manufacture sugar quite cheaply, and thus to procure an unlimited supply of one of the most valuable of all foodstuffs.

Lastly, a word may be said as to the future of chemical theory; but the subject need not detain us long, since it will be referred to in the chapter on physical chemistry. But we may note that the theoretical advance of the last few years makes it more than probable that the chemists of the future will be able to manufacture the so-called elements themselves at will. The conventional values at present attached to gold and silver will have to be readjusted. These precious metals will be manufactured only for their beauty and durability in the arts. But other metals, even more valuable, and far more useful, will be manufactured—metals such as platinum, and others, which have special properties that render them of use.

Relation of Chemistry to Electricity. Further, theoretical chemistry will become completely allied and unified with those branches of physics which we call electricity and magnetism. Already the old terms, such as *chemical attraction* and *chemical affinity*, are beginning to be ruled out of date, for we are learning that these *affinities* really depend not, as the old Greek thinker thought, upon the "loves and hates of the atoms," but upon the electrical properties of the different elements.

It is, indeed, not too much to say that the whole theory of chemistry will be resolved into a mere subdivision of the theory of electricity. This prospective advance has been already initiated by the study of radium and radioactivity. Indeed, it seems hardly too much to say that chemical theory will ere long reach a complete and final stage. The laws discovered by the students of the past hundred years will take their place beside and among the laws which the physicist has discovered. Let us remember our definition of the province of chemistry, and we shall see that the science which deals with the consequences of the fact that matter is of different kinds must plainly be resolved, at last, into the science which treats of matter of whatever kind. This is another way of saying that the *chemical forces* of which we now find it convenient to speak are not special and peculiar, but are none other than particular manifestations of the *physical forces* which act everywhere. The forces of *valency* and *affinity* and so forth, which we must study later, are already being regarded as merely particular expressions of that omnipresent force which we call electricity.

But though chemical theory will in all probability have become perfected in another century, no limit can be set to the possibilities of practical chemistry. The number of possible compounds which may be manufactured in the laboratories of the future is almost infinite. Nor can their utility to mankind be measured.

The Relations of the Elements. We cannot look at the periodic law without coming to the necessary conclusion that the elements are related; and we cannot philosophically come to this conclusion without being led to the further conclusion that their relationship implies common origin and an ultimate identity of nature. We have already seen that it is necessary to reject the simple hypothesis that the atoms of all the other elements are

compounded of atoms of hydrogen, and we come upon this final parting of the ways: either the periodic law means nothing, the relationship of the elements is only apparent, a mere matter of chance—or the atoms are not atoms. As everyone knows, it is to this last conclusion that Chemistry has been forced.

Atoms, Animals, and Plants. Professor George Darwin's Presidential Address to the Meeting of the British Association in South Africa in August of this year (1905) has clearly put before every reader the amazing analogy between the atoms of the elements and the individuals of any species of animal or plant. The elements are species, their atoms correspond to the individuals of species, and they are subject to change, to variation, to origin, and to disappearance, just like any living species, and in virtue of the same underlying causes and principles of evolution, of which the chief is natural selection—which chooses the individual organism or the individual atom that is the fittest to survive in the environment or the surroundings in which it is placed. We must later consider this theory of atomic evolution; meanwhile we note its incompatibility with the theory that atoms are ultimates. We must regard atoms, on the contrary, as fleeting phases of matter, none of which are eternal, even though some of them may last for millions of years. Here, then, we leave the periodic law, which has been invaluable to us, and will proceed to consider in brief the main characters of the principal elements, their distribution, the principles of their preparation, and their more important compounds.

Elements in the Free State. Some of the Elements are found in nature as such, or, as we say, in the *free state;* but more usually they are found as compounds which have to be decomposed before we can obtain and free the element. Three very important elements constitute by far the greatest part of the entire crust of the earth. These are *Silicon, Aluminium* and *Oxygen*—the latter of which the earth's crust has doubtless imprisoned from the atmosphere.

The greater bulk of the earth's atmosphere is made up of Oxygen and Nitrogen, each being in the free or uncombined state. Three more elements much less abundant, *Phosphorus, Sulphur,* and *Carbon,* are found widely spread in rocks and minerals and in sea water, though their total amount is small compared with that of the elements already named. Of these, however, the last—Carbon—is in some ways of supreme importance, for when we turn to the kinds of matter in which life is displayed, we find that carbon is the most abundant element therein. Now Silicon is the most abundant element in the *inorganic* or *lifeless* world; and it is possible to draw certain interesting comparisons between the chemical properties of this element Silicon and the element Carbon. We note this resemblance because it is of use in aiding the memory of the student, but we do not dwell upon it, because we must regard it as casual and not as possessed of the deeper significance which at first sight is certainly suggested.

Rarer Elements. All the remaining elements are relatively less abundant; even iron constitutes only a small portion of the earth's crust, though we think of it as such a common element. Radium, again, is almost infinitely rare; but we are learning in the case of Radium and other very rare elements to explain their rarity in a way which would have astonished the older chemists. Nowadays we regard them as rare merely because their lives are so short; and thus they make but a poor show when we come to make comparative estimates of the amounts of the various elements at any given moment. Lead, for instance, is by no means an uncommon element; certainly no one thinks of it as rare; but there is reason to believe that lead is actually no other than a very prolonged and therefore conspicuous stage in the evolution of certain atoms, radium representing a very brief stage in the earlier part of that evolution. This may be very loosely but graphically expressed in the saying that lead is the last stage of Radium. So much for the relative abundance of the elements, but to this we may add a brief table from Sir William Ramsay, the world-famous Professor at University College, London, which gives us some idea of the relative amounts of the elements that occur at the surface of the earth, including land, sea, and sky—that is to say, the earth's crust, the waters of the oceans, and the atmosphere:

Oxygen	50·0	Titanium	0·30
Silicon	25·3	Carbon	0·20
Aluminium	7·3	Chlorine	0·15
Iron	5·1	Phosphorus	0·09
Calcium	3·5	Manganese	0·07
Magnesium	2·5	Sulphur	0·04
Sodium	2·3	Barium	0·03
Potassium	2·2	Nitrogen	0·02
Hydrogen	1·0	Chromium	0·01

The Metals. An ancient and familiar division of the elements is into *metals* and *non-metals.* Everyone knows what the obvious characters of a metal are. It usually has a characteristic appearance or metallic lustre; it is usually heavy, and has physical properties which make it of practical value. The metals are exceptionally good conductors of heat and of electricity. In all these characters they are contrasted with the non-metals. All the metals are solid at ordinary temperatures with one exception, *Mercury.* This division of the elements is not strictly scientific, and very little further reference will be made to it, but we may here consider the common characters which make it convenient to retain the old name, and the few words we have to say will form a suitable introduction to the course on METALLURGY.

There are now known more than fifty metals, of which six were familiar to the ancients and are mentioned in the Bible; these are Gold, Silver, Tin, Copper, Iron, and Lead. In time past it was attempted to frame rigid definitions of the metals, and the first definition, now more than 1000 years old, insisted on the properties of fusibility and malleability as the essential characters of metals. Fusibility is the quality of undergoing liquefaction without other change

when great heat is applied. Malleability is the property in virtue of which a substance can be beaten out with a hammer (Latin *malleus*).

The Alchemists. The Alchemists paid immense attention to the metals because gold is a metal, and it was naturally from the other metals that they expected to be able to manufacture gold—an idea by no means so remote from possibility as we used to think. The fact of solidity was also regarded as essential to a metal; thus mercury was not regarded as a metal until it had been frozen—that is to say, solidified by cold. When Antimony and similar substances were discovered, they were regarded as semi-metals because they were not malleable, but brittle when struck with a hammer. Antimony, bismuth, and some other elements we often still speak of as metalloids—the termination *oid* implying *likeness*; it almost corresponds to the English "ish," and the metalloids are not exactly metals but *metallish*. However, that distinction was shown to be of small value, and the definition of a metal came to rest upon the possession of metallic lustre and of great weight; but many of the non-metals have a metallic lustre, and amongst the metals is the element lithium, which is actually the lightest solid known. Hence it is now impossible to form a satisfactory definition of the metals.

A Working Definition of Metals. We have dealt with this subject at none too great length because there is much instruction for us in the history of the changes which increasing knowledge has brought in our chemical conceptions. One by one the characters supposed to be essential to metals have had to be given up, and finally we see that there is no rigid demarcation in nature that corresponds to our rigid conception. But we may frame a "working definition" of the metals which is quite useful. We may say that a metal is a substance which in the first place combines with oxygen to form what we call an oxide. The character of these compounds with oxygen is that, as a class, they have a particular affinity for the compounds of non-metals with oxygen. The compounds of metals with oxygen are called *bases*; the compounds of non-metals with oxygen are called *acids; and the union of a base with an acid results in the formation of a salt*. This is a good definition, for instances can be adduced to show that certain of the elements are capable of acting either as metals or as non-metals in accordance with it. Sometimes the union of such a metal or metalloid with oxygen has a basic character and sometimes an acid character. So much for the metals in general. [See METALLURGY.]

To be continued

HOW TO USE APPARATUS IN CHEMISTRY

Electrolytic Apparatus. Sometimes in the course of his experimental work the chemist has occasion to decompose a substance by means of electricity.

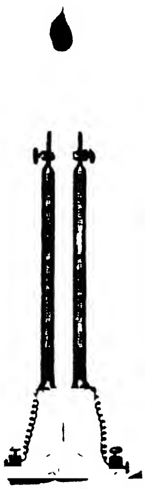
The instrument consists of three glass tubes united at one end. The two principal tubes form a U, and from the loop of the U the third tube springs parallel to the other two. The principal tubes terminate in little glass stop-cocks, while the third, or branch tube, tends in a bulb of sufficient capacity to hold the entire contents of all three tubes. The bulb is open at the top, and is about an inch above the stop-cocks. Two inches from the bend of the U a small piece of platinum foil is enclosed in each of the two principal tubes, and the foil is fastened to a platinum wire which is either fused into the wall of the tube passing through it, or passes through a small cork fitting into an opening in the slide of the tube.

In decomposing a fluid by means of electricity to electrolyse it, the fluid is poured into the bulb, the two stop-cocks being open, till the three tubes are full, though the bulb itself is empty. The stop-cocks of the principal tubes are then closed, and the wires from a powerful series of batteries are attached to the two little platinum plates. As the liquid is decomposed the gases arise in the principal tubes, and by their pressure drive the liquid up into the bulb.

Combustion Furnace. When resolving an organic compound into its elements to discover how much carbon, oxygen, hydrogen, and so forth there may be in it, we have to make use of a combustion furnace. There are a large number of furnaces in use, but they differ only in minor points of construction. Perhaps the most typical is that known as Erlenmeyer's furnace. This consists of twenty-four Bunsen burners, which lie beneath a fuel clay trough, on which the combustion tube lies. The combustion tube itself is simply a tube of very hard glass specially made for the purpose, and its exact form depends entirely upon the object of the analysis. It has either two straight ends, or one end is drawn out into a point and turned up. In either case it is laid on the fire-clay support, and cautiously attached to the auxiliary apparatus, which may be a gas holder for forcing air through it at one end, and a calcium chloride tube and potash bulbs at the other; or it may be an apparatus for collecting the nitrogen evolved. The order in which the different parts of the tube are heated also depends on the nature of the analysis, but the student will do well to be cautious in heating his tubes. If he is not careful he will cause them to bulge and possibly to crack. Again, by turning on the gas too suddenly he may crack the fire-clay support.

Heat Regulation. Besides requiring great heat, the chemist may find it necessary to keep an object at a fixed temperature. This is effected by means of gas regulators, working automatically. The principle of all these is this: An arrangement of glass tubes is made so that the gas has to pass over the face of some mercury on its passage to the burner. This mercury is in reality a thermometer, and as the temperature rises it tends to cut off the gas supply. Perhaps the best of these heat regulators is that made by Reichert, of Vienna, though quite efficient instruments can be made by the chemist himself.

To operate Reichert's regulator, the bulb of the thermometer tube is inserted in the oven, or flask, which should be maintained at a certain temperature. The auxiliary burner is placed beneath the object, being connected by tubing—preferably of metal, but often of india-rubber—to the regulator. A second thermometer is also inserted in the object. By means of an ordinary burner the temperature is raised to within a degree of the desired point. Then the common burner is removed, and the gas allowed to pass through the regulator, the pin-hole burner of which is lighted. After a few minutes the thermometer will reach the desired temperature, and the regulating screw must then be turned till the mercury is just touching the bottom of the inner tube. If, when that is done, the temperature of the oven or flask rises the slightest fraction above the indicated point, the mercury will cut off the gas and the pin-hole burner will keep the object just warm. At the same time, when the temperature falls below the selected point, the larger burner should be called into play and the heat at once increased. An hour's experimenting with one of these burners should enable the student to keep an oven at a fixed temperature day and night for weeks.

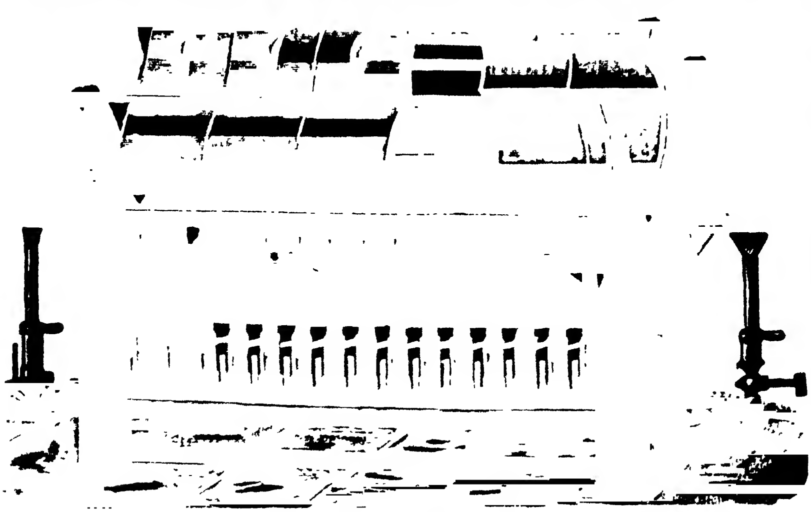


DECOMPOSING TUBE

Distillation. What is the importance of being thus able to regulate heat? It is important in many ways. In distillation much time and trouble is saved by this means. In many important operations of Organic Chemistry it is desirable to distil substances at varying temperatures. But first a word on the ordinary methods of distillation will be helpful.

The fluid to be distilled is placed in a retort which should be fitted with an extra tube through which a thermometer passes. The liquid should not fill more than a third of the retort. Overfilling these awkward vessels is responsible, perhaps, for more breakages than anything else. At the end of the retort is a condenser, through which a stream of water continually passes, and the condenser ends in the flask destined to receive the distillate. Note that the end of the retort must be fitted to the condenser with a cork or rubber tubing, but unless the distillate is very volatile there is no need in general practice for the condenser to be united to the receiver; in fact, in most cases it is preferable that it should be quite free in the neck of the flask. In simple distilling the liquid is heated to its boiling point, and there kept boiling briskly, while the vapour passes over the condenser and returns to the fluid state.

In fractional distillation the matter is different. It is generally preferable to use a flask fitted with a cork through which two holes are bored. Through one of these holes the thermometer of the heat regulator is passed, and through the other is passed a wide glass tube having a branch tube bent downwards, reaching out of its side. In the upper half of this tube we fit our standard thermometer, closing the top and taking care that when the desired temperature is reached the column of mercury in the thermometer shall just pass through the cork. The bent side-tube is attached to the condenser. Then the liquid in the flask is brought to the lowest of the temperatures at which we wish to distil, the gas regulator is adjusted, and the operation progresses automatically. When nothing more can be seen dripping into the receiver, allow five minutes to pass, put on a clean receiver, unscrew the regulator of the gas controller, raise the temperature to the next point, and repeat these operations till the temperature has been successfully dealt with. It is always advisable to allow five minutes' grace; many a promising distillation has been ruined by over haste.



COMBUSTION FURNACE

LATIN. ENGLISH. GERMAN

Latin and English, by G. K. HIBBERT, M.A., Classical Master at Broadgate School, Nottingham; German, by Dr. OSTEN, Dramatist, and P. G. KONODY

LATIN

By Gerald K. Hibbert, M.A.

Section I. GRAMMAR

Nouns: Fourth Declension: *-u* stems. [The Third Declension will be taken next lesson.] Nominative ends in *-us* (mostly masculine) and in *-u* (always neuter).

	Singular.	*Plural.*
N. V.	gradus, *a step*	gradūs
Acc.	gradum	(gradūs)
Gen.	gradūs	graduum
Dat.	gradui	gradibus
Abl.	gradu	(*or* gradubus)
N. V. A.	genu, *a knee*	genua
Gen.	genūs	genuum
Dat.	genu	genibus
Abl.	genu	(*or* genubus)

A few nouns of this declension ending in *-us* are feminine: *e.g.*, *manus* (hand), *acus* (needle), *domus* (house), *tribus* (tribe), *porticus* (porch), *anus* (old woman). *Domus* makes dat. sing. *domui* or *domo*, abl. *domo*, acc. pl. *-us* or *-os*, gen. *domuum* or *domorum* (partly second and partly fourth declension).

Fifth Declension: *-e* stems.

All nouns in this declension have nominative in *-es*, and are feminine (except *dies*, which is common gender in singular, and masculine in plural).

	Singular.	*Plural.*
N. V	dies (*day*)	dies.
Acc.	diem	dies.
Gen.	diei	dierum
Dat.	diei	diebus
Abl.	die	diebus

Pronouns — Personal: (purely substantives).

First Person

	Singular.	*Plural.*
Nom.	ego, *I*	nos, *we*
Acc.	me, *me*	nos, *us*
Gen.	mei, *of me*	*nostri, *or* nostrum, *of us*
Dat.	mihi, *to* or *for me*	nobis, *to* or *for us*
Abl.	me, *by me, etc.*	nobis, *by us, etc.*

Second Person

	Singular.	*Plural.*
Nom.	tu, *thou*	vos, *ye*
Acc.	te, *thee*	vos, *you*
Gen	tui	*vestri *or* vestrum
Dat.	tibi	vobis
Abl.	te	vobis

* Note. *Nostrum* and *vestrum* are *Partitive* genitives—that is, used in phrases like "many of us" (*multi nostrum*), "two of you" (*duo vestrum*), where the genitive stands to the nominative in the relation not of a possessor, but of a whole to a part. But "love of us" would be *amor nostri.*

Third Person

For *he, she, it*, the Demonstrative Pronouns *hic*, *is*, or *ille* (see below) are used. Thus, masculine *hic* (he), feminine *haec* (she), neuter *hoc* (it).

Demonstrative. Used either as adjectives or substantively: thus (1) *hic puer* = this boy, (2) *hic* = he.

1. Simple or Unemphatic.

Singular.

	Masc.	*Fem.*	*Neut.*
Nom.	is (*that*, or *he*)	ea (*she*)	id (*it*)
Acc.	eum	eam	id
Gen.	ejus	ejus	ejus
Dat.	ei	ei	ei
Abl.	eo	ea	eo

Plural.

Nom.	ii	eae	ea
Acc.	eos	eas	ea
Gen.	eorum	earum	eorum
Dat.	iis *or* eis (*all genders*)		
Abl.	iis *or* eis		

2. Emphatic

Hic, this (near me): the demonstrative pronoun of the first person.

Singular.

Nom.	hic	haec	hoc
Acc.	hunc	hanc	hoc
Gen.	hujus		
Dat.	huic		
Abl.	hoc	hac	hoc

Plural.

Nom.	hi	hae	haec
Acc.	hos	has	haec
Gen.	horum	harum	horum
Dat.	his		
Abl.	his		

Iste, that (near you): the demonstrative pronoun of the second person. (Often used contemptuously—*e.g.*, *isti* = those contemptible friends of yours. In law, *hic* = my client, *iste* = my opponent, the defendant.)

Singular.

Nom	iste	ista	istud
Acc.	istum	istam	istud
Gen.	istius		
Dat.	isti		
Abl.	isto	ista	isto

Plural.

Nom.	isti	istae	ista
Acc.	istos	istas	ista
Gen.	istorum	istarum	istorum
Dat.	istis		
Abl.	istis		

Ille, that (near him): the demonstrative pronoun of the third person = that yonder, that out there. (Often means "the distinguished": *Cato ille* = the great Cato.) Declined like *iste*.

Definitive.

Idem, the same: (compound of *is* and *dem*.)

Singular.

	Masc.	*Fem.*	*Neut.*
Nom.	idem	eadem	idem
Acc.	eundem	eandem	idem
Gen.		ejusdem	
Dat.		eidem	
Abl.	eodem	eadem	eodem

Plural.

Nom.	eidem	eaedem	eadem
Acc.	eosdem	easdem	eadem
Gen.	eorundem	earundem	eorundem
Dat.		eisdem	
Abl.		eisdem	

Ipse, self. Declined like *ille*, except that the neuter sing. nom. and acc. is not *ipsud*, but *ipsum*. Examples of its use: *ego ipse* = I myself; *illo ipso die* = on that very day. It can be used of any person (with *ego*, *tu*, etc.) and in any case.

Reflexive. (Third Person.)

Singular and Plural.

Nom.	(wanting: use *ipse* for "he himself.")
Acc.	se (*or* sese), *himself, herself, itself, themselves.*
Gen.	sui, *of himself*, etc.
Dat.	sibi, *to* or *for himself*, etc.
Abl.	se (*or* sese), *with himself*, etc.

Possessive.

Singular.

	Masc.	*Fem.*	*Neut.*	
1*st person*	meus	mea	meum	(*my, mine*)
2*nd person*	tuus	tua	tuum	(*thy, thine*)
3*rd person* (*Reflexive only*)	suus	sua	suum	(*his own, her own, etc.*)

Plural.

1*st person*	noster	nostra	nostrum	(*our*)
2*nd person*	vester	vestra	vestrum	(*your*)
Also	cujus	cuja	cujum	(*whose*)

Decline *meus, tuus, suus*, and *cujus* like *bonus*; *noster* and *vester* like *niger*. *Meus* has vocative masc. *mi*; *tuus* and *suus* have none.

NOTE. *Suus* is reflexive only, and cannot be used for the ordinary possessive of the third person. *Se* and *suus* can only be used when the person they denote is the same as the nominative to the principal verb in the sentence in which they occur, as "Brutus killed *himself* (*se*) with *his own* (*suo*) dagger." For the ordinary third person possessive use genitive of *is, hic*, or *ille*; thus, *sumus ejus servi* = we are his slaves.

Verbs. Latin verbs, like English, have two voices, Active and Passive; two numbers, singular and plural; and three persons in each number, thus 1st pers. *amo*, I love; 2nd, *amas*, thou lovest; 3rd, *amat*, he loves. Note that the pronouns *ego, tu*, etc., are not expressed, but are implied by the different personal endings.

SCHEME OF THE FOUR CONJUGATIONS.

[*Must* be learnt by heart.]

There are four regular Conjugations:

Conjugation.		*Pres. Indic.*	*Infinitive.*	
1*st*	*A-verbs*	amo	amA-re	*I love*
2*nd*	*E-verbs*	moneo	monĒ-re	*I warn*
3*rd*	*Consonant or U-verbs*	rego induo	reG-ĕre indU-ĕre	*I rule* *I put o*[n]
4*th*	*I-verbs*	audio	audI-re	*I hear*

Active Voice.

Indicative Mood.

	Singular.			*Plural.*	
	1*st person*	2*nd*	3*rd*	1*st*	2*nd*	3*rd*

PRESENT.

Am-o	as	at	amus	atis	ant
(*I love, or am loving, etc.*)					
Mon-eo	es	et	emus	etis	ent
(*I warn, or am warning, etc.*)					
Reg-o	is	it	ĭmus	ĭtis	unt
(*I rule, or am ruling, etc.*)					
Aud-io	is	it	imus	itis	iunt
(*I hear, or am hearing, etc.*)					

FUTURE SIMPLE.

Amā- Monē- } bo	bis	bit	bimus	bitis	bunt
(*I shall love, or warn, etc.*)					
Reg- Audi- } am	es	et	emus	etis	ent
(*I shall rule, hear, etc.*)					

IMPERFECT.

Ama- Monē- Regē- Audiē- } bam	bas	bat	bamus	batis	bant
(*I was loving, etc.*)					

PERFECT.

Amav- Monu- Rex- Audiv- } i	isti	it	imus	istis	ērunt (*or* ēre)
(*I have loved, or I loved, etc.*)					

FUTURE PERFECT.

Amav- Monu- Rex- Audiv- } ero	eris	erit	erimus	eritis	erint
(*I shall have loved, etc.*)					

PLUPERFECT.

Amav- Monu- Rex- Audiv- } eram	eras	erat	eramus	eratis	erant
(*I had loved, &c.*)					

Subjunctive Mood.

PRESENT.

Am-em	es	et	emus	etis	ent
Mon-eam	eas	eat	eamus	eatis	eant
Reg-am	as	at	amus	atis	ant
Aud-iam	ias	iat	iamus	iatis	iant

IMPERFECT.

Ama- Monē Regĕ- Audi- } rem	res	ret	remus	retis	rent

	Singular.			*Plural.*	
	1st person	*2nd*	*3rd*	*1st*	*2nd*	*3rd*

PERFECT.

Stems	1st	2nd	3rd	1st	2nd	3rd
Amav- Monu- Rex- Audiv-	erim	eris	erit	erimus	eritis	erint

PLUPERFECT.

Stems	1st	2nd	3rd	1st	2nd	3rd
Amav- Monu- Rex- Audiv-	issem	isses	isset	issemus	issetis	issent

Imperative Mood.

PRESENT TENSE—

2nd sing.	*2nd plural.*
Ama (*love thou*)	Amate (*love ye*)
Monē	Monete
Regĕ	Regite
Audi	Audite

FUTURE TENSE—

2nd sing.	*3rd sing.*	*2nd pl.*	*3rd pl.*
amato	amato	amatote	amanto
(*thou must love, &c.*)			
moneto	moneto	monetote	monento
regito	regito	regitote	regunto
audito	audito	auditote	audiunto

Infinitive Mood.

PRES. AND IMPERF.		PERF. AND PLUPERF.	
ama- monē- regĕ- audi-	rĕ (*to love, &c.*)	amav- monu- rex- audiv-	isse (*to have loved, &c.*)

Gerund (VERBAL NOUN).

	Nom. and Acc.	*Gen.*	*Dat. and Abl.*
amand- monend- regend- audiend-	um	i	o

Participles.

PRESENT.	FUTURE.
amans, *loving*	amaturus, a, um
monens	moniturus, a, um
regens	recturus, a, um
audiens	auditurus, a, um

Supines.

amatum	amatu
monitum	monitu
rectum	rectu
auditum	auditu

NOTE. The Gerund and the two Supines are verbal nouns or substantives, supplying cases to the infinitive: thus, *spes regendi* (genitive of the gerund *regendum*) = the hope of ruling; *mirabile auditu* (abl. of supine) = wonderful to hear.

The participles are verbal adjectives, and are declined as such: future participles like *bonus*, present participles like *ingens* (see next lesson).

The present, perfect, and supine stems must be known in order to conjugate a verb; from these the other parts of the verb may be formed. Therefore it is well to learn what are called the Principal Parts of every verb: that is, the present infinitive, the perfect indicative, and the supine in -*um*. Thus of *amo* the principal parts are *amare, amavi, amatum*. The following table will be found useful for reference, showing how all the tenses (both active and passive) are derived from these three principal parts:

DERIVATION OF THE VERB FORMS.

From Present Infinitive stem.

Pres. act. and pass.	Infin. pres. a. and p.
Fut. simple a. and p.	Gerund and gerundive
Imperf. a. and p.	Participle pres. act.
Imperative a. and p.	

From Perfect stem.

Perfect active	Pluperfect active
Fut. perf. active	Infin. perf. active

From Supine stem.

Supines	Perfect pass.
Fut. part. act.	Future perf. pass.
Fut. infin. pass.	Pluperf. pass.
Perf. part. pass.	Perf. Infin. pass.

Notice that the Imperative Active is formed by dropping the *re* from the Present Infinitive: *amare, ama; audire, audi*, etc.

Note also: The Present, Future, and Present Perfect (*i.e.* "*amavi*" translated "I have loved," not "I loved") are called *Primary* tenses; the Imperfect, Pluperfect, and simple Perfect ("*amavi*," "I loved"), Historic tenses.

SECTION II. SYNTAX.

RULE 1. If one verb is predicated of two or more subjects, it will be in the plural—*e.g., Puer et puella equum amant* = the boy and the girl love the horse.

RULE 2. If there are two or more subjects of different grammatical persons, the verb agrees with the first person rather than the second, and with the second rather than the third—*e.g., Si tu et Tullia valetis, ego et Cicero valemus* = if you and Tullia are well, Cicero and I are well. [NOTE. The Romans put "I" first: they said, "*ego et Caius*," where we say, "Caius and I." Therefore when Wolsey wrote "*Ego et rex meus*," he was a good scholar, though a poor courtier.]

RULE 3. When an adjective qualifies nouns of different genders, it agrees with the masculine rather than with the feminine—*e.g., Frater mihi* (or *meus*) *et soror mortui sunt* = my brother and sister are dead. If the subjects are all lifeless things, no matter what their gender, the adjective is neuter—*e.g., Divitiae et gloria jucunda* (neut. pl.) *sunt* = riches and glory are pleasant.

SENTENCES TO BE PUT INTO LATIN.

Both ... and—Et ... et.	**Therefore**—Ergo.
Wind—Ventus, -i.	**Money**—Pecunia.
Storm—Procella.	**I show**—Monstro, -are.
Dream—Somnium.	**Wisdom**—Sapientia.
Experience—Experientia.	**Many**—Multi (*pl.*).
I hope—Spero, -are.	**I blame**—Culpo, -are.
Too much—Nimis.	**Deed**—Factum.
Less—Minus.	**I lead**—Duco, ducere.
I give—Do, dare, dedi, datum.	**Desired**—Optatus, -a, -um.
I say—Dico, dicere, dixi, dictum.	**Haven**—Portus, -ûs.

1. God rules both the winds and the storms.
2. This thing (omit "thing," and put "this" in neuter) is not the same as (*ac*) that, and never (say "nor ever," *neque unquam*) will be.
3. In (his) dreams he heard himself warning his friends.
4. Experience warns us not (use *ne* with subjunctive mood, negative of *ut*) to hope too much.

5. If she had loved (subjunctive) herself less, she would have been happy.

6. Both you and I will warn this boy not to give (his) books to that poet (say, as in No. 4, "that he may not give," using *ne*).

7. Cæsar himself has said it: therefore it is true.

8. Love glory and not money: so (*ita*) shalt thou show true wisdom.

9. Many of us will blame you on account of this day's deeds.

10. Through waves and storms God leads us to the desired haven.

KEY TO THE ABOVE SENTENCES.

1. Deus et ventos et procellas regit.
2. Hoc non est idem (*neut.*) ac illud, neque unquam erit.
3. In somniis se audivit amicos monentem (*acc. of present participle, agreeing with* se).
4. Experientia nos monet ne nimis speremus.
5. Si se (*or* ipsam) minus amavisset, fuisset beata.
6. Et ego et tu hunc puerum monebimus ne libros illi poetae det.
7. Caesar ipse hoc dixit: ergo verum est.
8. Ama gloriam, non pecuniam: ita veram sapientiam monstrabis.
9. Multi nostrum te (*or* vos) ob hujus diei facta culpabimus.
10. Per undas et procellas (*or* procellasque) Deus nos ad optatum portum (*not* dative) ducit.

SECTION III. TRANSLATION.

VOCABULARY.

Monumentum, -i—A monument.
Quaero, -ere—I seek.
Circumspicio — I look round.
Regnum—A kingdom.
Mundus, -i—World.
Minister, -ri—Servant.
Certo, -are—I strive.
Alius, -a, -um—Other.
Laudo, -are—I praise.
Recipio, -ere—I receive.
Visus, -ûs—Sight.
Fides, -ei—Faith.
Servo, -are—I save.
Regno, -are—I reign.
Sed—But.
Dormio, -ire—I sleep.
Ambulo, -are—I walk.
Seculum—Generation.
Venio, -ire—I come.
Voluntas — Will (*Nominative*).
Sicut—As.
Caelum—Heaven.
Terra—Earth.

SENTENCES TO BE TRANSLATED INTO ENGLISH.

1. Si monumentum quaeris, circumspice.
2. Regnum meum non est ex hoc mundo: si ex hoc mundo esset regnum meum, ministri mei certavissent.
3. Multi alios laudant, ut ab illis laudentur (*pres. subj. passive of* "laudo").
4. Et Jesus dixit ei, Recipito visum: fides tua te servavit.
5. Nero post Tiberium, sed ante Vespasianum regnavit.
6. Dormiens ambulabat.
7. Amavisse non idem est ac amare.
8. Illi (*dat. sing.*) sit gloria in secula seculorum.
9. Veniat regnum tuum; fiat (= *let be done*) voluntas tua, sicut in caelo, ita etiam in terra.
10. Ama hanc puellam, sed mone illum puerum ne stultus (*foolish*) sit.

KEY TO THE ABOVE SENTENCES.

1. If you seek a monument, look around.
2. My kingdom is not of (literally "from") this world; if my kingdom were of this world, my servants would have striven (*si* usually takes subjunctive).
3. Many men praise others, in order that they may be praised by them.
4. And Jesus said to him, Receive (thy) sight: thy faith has saved thee.
5. Nero reigned after Tiberius, but before Vespasian.
6. He used to walk (note the force of the imperfect) in his sleep (literally "sleeping," pres. part. of *dormio*).
7. "To have loved" is not the same (thing) as "to love."
8. To him be the glory for generations of generations (a frequent use of *in* = during, for).
9. Let thy kingdom come: let thy will be done, as in heaven, so also on earth.
10. Love this girl, but warn that boy not to be foolish (that he may not be; *ne* is negative of *ut*, which = in order that).

To be continued

ENGLISH

By Gerald K. Hibbert, M.A.

Number. In English there are only two numbers, Singular and Plural. A noun is said to be Singular when it denotes a single object, and Plural when it denotes two or more things of the same kind—*e.g.*, *book*, *books*.

The plural is formed from the singular in several ways.

1. By far the commonest method is to add *es* (Anglo-Saxon *as*) to the singular: this becomes *s* when the pronunciation admits of it.

a. The full syllable *es* is added only when the singular ends in a sound of *s*—*i.e.*, *s sh*, soft *ch*, *x*, *z*. Examples: *churches*, *foxes*, *lashes* (but *monarchs*).

b. The letters *es* are also added after several words ending in *-o* (*cargoes*, *potatoes*), and one in *-i* (*alkalies*); but they are not sounded as a separate syllable in this or the two following cases. (A few words in *-o* simply add *-s*, as *solo*, *tyro*, *canto*, *grotto*, *quarto*, *octavo*, and all in *-io* and *-oo*.)

c. *-es* is also added after *y* preceded by a consonant, the *y* being changed to *i*: *body, bodies*. *Qu* counts as a consonant: *soliloquy, soliloquies*. But if a vowel precedes the *y*, *-s* alone is added, the *y* remaining unchanged—*e.g., chimneys, boys, moneys* (avoid the spelling *monies*).

d. *-es* is also added to words of Anglo-Saxon origin ending in *f, fe*, and *lf*, preceded by any long vowel sound except *oo*, and the *f* is changed into *v*. Examples: *life, lives*; *calf, calves*; *loaf, loaves*. But nouns in *oof, ff, rf*, and nouns in *f* of Norman-French origin, take simple *-s*, and retain the sharp sound of the *f*—*e.g., chiefs, roofs, skiffs, turfs, reefs*.

NOTE: *thief, thieves*; *staff, staves*; *wharf, wharves*; *scarf, scarves*.

All other nouns except those to be immediately mentioned add *s* to the singular—*e.g., cats* (sharp *s*), *dogs* (flat *s*).

2. By adding *-en*, as *ox, oxen*; *brother, brethren*; *child, children* ("children" is a double plural, the old English plural being "childer"); *eye, eyne* (Spenser, Shakespeare); *shoe, shoon*; *cow, kine*; *hose, hosen*.

3. By changing the vowel sound of the word, as *man, men*; *foot, feet*; *mouse, mice*; *tooth, teeth*. To this head also belong *brethren* and *kine*, as well as to 2.

4. By leaving the singular unchanged—*e.g., sheep, deer, swine*. *Cf.* also: twenty *brace* of partridges, ten *thousand* horse (*i.e.* cavalry), ten *sail* of the line.

DOUBLE PLURALS. Some nouns have two plurals, differing in meaning.

Brother	Brothers (*by birth*)	Brethren (*of a society*)
Die	Dies (*for stamping*)	Dice (*for play*)
Penny	Pennies (*separate coins*)	Pence (*lump sum*)
Index	Indexes (*of a book*)	Indices (*in Algebra*)
Pea	Peas (*separate seeds*)	Pease (*collective*)
Genius	Geniuses (*gifted men*)	Genii (*spirits, ghosts*)
Cloth	Cloths (*kinds of cloth*)	Clothes (*garments*)

NOUNS USED ONLY IN SINGULAR. Names of materials or substances, and of qualities: as *water, gold, humour*. These nouns can, of course, take a plural, denoting different sorts of the same thing—*e.g., mineral waters*.

NOUNS USED ONLY IN PLURAL. Names of instruments or articles of dress made double (*scissors, trousers*); portions of the body, diseases, games, ceremonies, etc. (*entrails, mumps, billiards, matins*).

NOUNS IN SUSPENSE BETWEEN SINGULAR AND PLURAL. *Alms* (Old English *aelmesse*), *riches* (French *richesse*), and *eaves* (Old English, *efese*) are really singular, though often treated as plural—*e.g.*, "Who asked *an* alms"; "Riches fineless [endless] *is* as poor as winter, To him that ever fears he shall be poor."

Amends, means, news, pains, wages, are strictly plural, but are often used as singular—*e.g.*, "The wages of sin is death"; "A means to an end"; "To make an amends." *News* is now always singular: "Ill news flies apace" (*cf.* "These ill news," in Shakespeare).

Small-pox is strictly a plural, from singular *pock*.

PLURALS OF COMPOUND NOUNS. In most compounds the constituent parts have so completely coalesced that there is no difficulty about forming the plural in the ordinary way—*e.g., rain-bow, rain-bows, horse-box, horse-boxes*.

But compounds of a noun and an attributive word or phrase, in which the parts have not coalesced into a single word, add the *-s* to the noun—*e.g., courts-martial, knights-errant, fathers in-law*. When the compound consists of *two nouns* imperfectly coalesced both take the sign of the plural—*e.g., knights-templars, men-servants, lords-lieutenants, lords-justices*.

PLURALS OF FOREIGN WORDS. A number of nouns borrowed from foreign languages retain their proper plurals. Thus:

LATIN.

Nouns in *a*	make *æ*:	nebula, nebulæ
„ *um*	„ *a*:	erratum, errata
„ *is*	„ *es*:	axis, axes
„ *ix* (*ex*)	„ *ices*:	vertex, vertices; appendix, appendices
„ *us* (masc.)	„ *i*:	terminus, termini
„ *us* (neut.)	„ *era*:	genus, genera
„ *ies*	„ *ies*:	series, series

GREEK.

Nouns in *on*	make *a*:	phenomena, automata
„ *sis*	„ *ses*:	crises, parentheses
„ *ma*	„ *mata*:	miasmata

MISCELLANEOUS. Cherub, cherubim; seraph, seraphim; beau, beaux; madame, mesdames; bandit, banditti; virtuoso, virtuosi.

Case. Cases are the different forms which a Noun or Pronoun assumes to denote its relation to other words in a sentence. In Modern English we have three cases, *Nominative, Possessive, Objective*.

In Anglo-Saxon there were five cases, as in Latin—Nominative, Genitive, Dative, Accusative and Instrumental (or Ablative). The last was retained only in pronouns and dropped in nouns; the Dative gradually came to be used for the Accusative as well as for itself, and was called the Objective. The Possessive represents the old Genitive.

The *Nominative* is the case of the Subject of the sentence, and denotes the person or thing about which we are speaking. It answers the question *Who?* or *What?*—*e.g.*, "Time flies." When the Nominative names the person spoken *to*, rather than *of*, it is called the Nominative of Address, or sometimes the Vocative (*voco* = I call)—*e.g.*, "*Son*, go work in my vineyard."

The *Possessive* is the Case by which we show that something belongs to the person or thing for which it stands—*e.g.*, "Joseph's brethren." It is the only case in nouns in which a case suffix is now used. The Possessive Case in the

singular, and in those forms of the plural not ending in *s*, is formed by adding *'s* to the nominative case—*e.g.*, "Women's rights." But when the plural ends in *s*, the possessive is indicated in writing by putting the apostrophe after the *s*, as "boys' clothes."

NOTE. The use of the apostrophe is modern. The old Possessive suffix was *es* (seen in Wednesday—*i.e.*, Wodenes day), and the apostrophe shows that the *e* has been dropped. The *'s* is *not* an abbreviation of *his*: so "For Jesus Christ His sake" is incorrect.

The simple apostrophe is sometimes used with singular nouns that end in an s sound—e.g., for justice' sake; for righteousness' sake. This is admissible, but we must write "Chambers's Journal," not "Chambers' Journal," for we do not omit the *'s* in speaking.

In the case of a complex name, the possessive suffix is attached only to the last word of the name—*e.g.*, "The Prince of Wales's carriage"; "With Mr. and Mrs. Brown's compliments."

The *Objective* Case is that form of a noun (or pronoun) which denotes that the noun or pronoun stands for the object of the action indicated in some verb in the active voice, or which comes after a preposition. A noun is therefore in the Objective Case when it is the object of a verb or is governed by a preposition. The Objective Case answers the question "*Whom? What?*" In Nouns the Objective Case is the same in form as the Nominative; usually, therefore, we distinguish the two by their position in the sentence, the Nominative coming before the verb, and the Objective after—*e.g.*, "Manners (nom.) maketh man (obj.)"; "Daniel (nom.) was in the den (obj. after *in*) of lions."

The Objective, besides representing the Latin accusative (direct object, as above), also represents the Latin dative (indirect object, *to* or *for*) —*e.g.*, "Tell me the old, old story," where *me* is indirect and *story* direct object; "Saddle *me* the ass"; "He answered *him* never a word"; "He plucked *me* (for me) ope his doublet"; "Knock *me* (for me) at this gate."

Syntax of the Noun. The Syntax of the noun deals with the manner in which a noun is related to the other words in a sentence.

NOMINATIVE CASE.

1. Complementary Nominative. The verbs *to be, to become*, and Passive verbs of *naming, making, appointing, deeming*, &c., take a nominative after them as well as before: "Is it *I*?"; "John the Baptist is called *the Elijah* of the New Testament." In colloquial language we say, "It's me," "That's him," but such expressions are incorrect.
2. Nominative Absolute (corresponding to Ablative Absolute in Latin, and Genitive Absolute in Greek). The Nominative may be used with a Participle, forming with it a clause *grammatically* independent of the rest of the sentence, *i.e.* an *absolute* clause —*e.g.*, "They pressed on into the heart of the mountains, *the scenery becoming more and more sombre at every step*." This sentence is complete grammatically, even if we omit the words in italics. Similarly, in "Paradise Regained:"

   "And when to all his angels he proposed
   To draw the proud king Ahab into fraud,
   That he might fall in Ramoth, *they demurring*,
   I undertook that office."

   The participle is sometimes omitted: "Yet he himself, *time to himself best known*, Remembering Abraham, etc." ("Paradise Regained"), where "being" is omitted before "best known."

POSSESSIVE CASE. This is rarely used except where the Noun denotes a living thing: in such expressions as "the cannon's mouth," "the Church's one foundation," the objects are personified. Traces of the old genitive case (which the Possessive replaced) are seen in "a month's notice," "a day's wages," "at their wit's end."

In familiar language the Possessive is often used alone, without the noun on which it depends: as "St. Paul's" (Cathedral), "Prince's" (Restaurant), "a poem of Tennyson's."

OBJECTIVE CASE.

1. The Objective usually follows the verb, but when it differs in form from the Nominative it may stand before the verb, without causing any ambiguity: as "He saved others: *himself* he cannot save."
2. Verbs of *making, appointing, calling, thinking* take a *Complementary Object* in addition to the direct object: as, "They hailed him (direct) father (compl. obj.) of a line of kings."
3. The verbs *ask, teach, forgive, banish*, etc., often take a second Objective—*e.g.*, "We banish you our territories"; "I ask you pardon." These verbs can take an Objective even in the Passive Voice: "He was denied his rights."
4. The Cognate Objective, or Objective of kindred meaning, is used after many *intransitive* verbs: "I have fought the good fight"; "He laughed his great laugh." There is, of course, here a transitive force in the verb.
5. The Objective is used after intransitive verbs and after adjectives to denote extent, duration, age, value: as "The plain stretched *miles* in each direction."
6. The objective is used after certain old Impersonal Verbs, when it is the virtual, though not the grammatical subject—*e.g.*, "It repenteth *me* that I have set up Saul to be king" (= I repent).

APPOSITION. When two or more nouns are used together, as names of the same thing, they are said to be in Apposition; they are always of the same *case*. "So hand in hand they passed, *the loveliest pair*" (nominative).; "We have found him of whom Moses . . . did write, *Jesus of Nazareth*" (objective).

Sometimes a Noun stands in apposition to a whole sentence: "They dragged her away shrieking, *a sight* to move the hardest heart."

CORRECT THE FOLLOWING SENTENCES:

1. The boy stood on the burning deck,
   Whence all but he had fled.
2. Whom do men say that I am?
3. This injury has been done me by my friend, he whom I treated like a brother.
4. Oh, a cherubim thou wast that did preserve me.
5. Where nothing save the waves and I
   Shall hear our mutual murmurs sweep.

To be continued

GERMAN

By P. G. Konody and Dr. Osten

THE German and English languages are connected by descent. The English is derived from the Old Saxon, one of the branches of the ancient Teutonic languages.

But historical influences, principally the influx of Latin elements due to the Norman Conquest, and the self-acting processes of natural development, have extensively altered the English language. By suppressions, insertions, inflections and manifold other alterations, phonetic and structural, the English language has performed her individualisation. The two languages reveal at present only superficial affinities, and differ fundamentally in the pronunciation, as well as in the rules of transformation, in the different categories of words which, according to the modifications of quantity, gender, and tense, have to be produced.

One of the most remarkable differences may be noticed in the intensity of sound needed for forming German and English words. German sounds far louder than English, as may be easily perceived by anybody frequenting some German assembly. This phenomenon is due to the fact that the German produces his words in the middle and at the back of his mouth, whilst English words are produced in the front. The difference is, of course, due to the nature of the sounds themselves, which in German comprise gutturals and compounds unknown in English.

The principal objects the English student of German ought to keep in view at the beginning are the careful study of the pronunciation, and the regular and constant enlargement of his stock of German words. The German language contains an enormous number of words, and the perfect command of a certain amount of vocables, gradually extended according to the general progress, seems indispensable.

As regards the German pronunciation, the student should not be discouraged by the initial difficulties, which consist mainly in producing sounds which have no equivalent in English. Once he has mastered these sounds, all will be plain sailing, as every letter has practically only one pronunciation, and every written or printed letter is clearly sounded. Such variations in the pronunciation of the same letters in English, as the *a* in ball, have, far, dance; or the *ough* in rough, plough, cough, dough, thorough, and through, could never occur in German. The student should make it a point from the very beginning to practise the clear, clean pronunciation of the German vowels, which must be conceived as strictly isolated sounds, while in English they are frequently toned down, a very slight *y* being sounded after the *e*, or a *u* after the *o*.

To each explanation in the following chapters the necessary instances are given of selected vocables, which must be learnt by heart and recapitulated daily. Moreover, the student will find abundant practice in translations from one language into the other. The length of the vowels, and the stress which has to be laid on decisive syllables, or words, in compounds, are indicated by separate signs. The principal rules must, of course, be thoroughly remembered, as well as the main features of the numerous exceptions, of which the complete command can only be acquired by practical experience.

An examination paper, with a key, will be given at the end of each lesson.

PRONUNCIATION.

Signs used for indicating the pronunciation: Long, ¯; short, ˘; very short, °; stress, ʹ; division of syllables and of compound words, -.

THE PRINTED LETTERS (TYPES).—The German types are cut in the characteristic Gothic style, and differ from the Latin types used in the English language by their pointed shape, but the difference is in some cases very slight. The following small letters can be easily recognised by their close similarity with their Latin equivalents:

Latin types: b, c, e, g, i, j, l, m, n, o, p, q, r, s,
German types: 𝔟, 𝔠, 𝔢, 𝔤, 𝔦, 𝔧, 𝔩, 𝔪, 𝔫, 𝔬, 𝔭, 𝔮, 𝔯, 𝔰,

Latin types: t, u, w, y;
German types: 𝔱, 𝔲, 𝔴, 𝔶.

The other letters of the small alphabet appear somewhat differently shaped:

Latin types: a, d, f, h, k, s, v, x, z;
German types: 𝔞, 𝔡, 𝔣, 𝔥, 𝔨, ſ, 𝔳, 𝔵, 𝔷.

The capitals show essentially distinctive forms, except those of rotund character—D, O, Q, U.

Latin Capitals: A, B, C, D, E, F, G, H, I,
German Capitals: 𝔄, 𝔅, ℭ, 𝔇, 𝔈, 𝔉, 𝔊, ℌ, ℑ,

Latin Capitals: J, K, L, M, N, O, P, Q, R,
German Capitals: 𝔍, 𝔎, 𝔏, 𝔐, 𝔑, 𝔒, 𝔓, 𝔔, ℜ,

Latin Capitals: S, T, U, V, W, X, Y, Z;
German Capitals: 𝔖, 𝔗, 𝔘, 𝔙, 𝔚, 𝔛, 𝔜, ℨ.

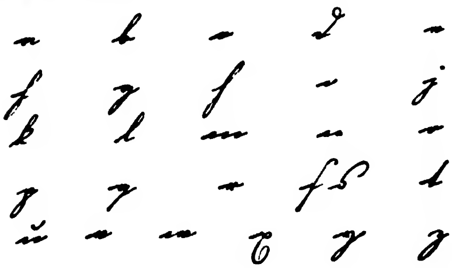
The letters of German handwriting differ greatly from the printed Gothic types; but though a knowledge of them will be found distinctly useful, it is not absolutely essential, as everybody in Germany is able to read Latin characters, which are now frequently used in writing. It will therefore only be necessary for the student to be able to *read*, not to write German handwriting. Even in printing, the use of Latin type is spreading more and more in Germany, especially in works of science and in the economic part of newspapers.

Beware of confounding the following very similar letters:

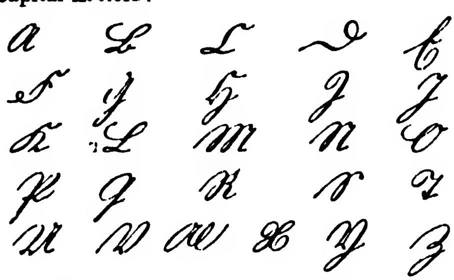
𝔟 and 𝔥; 𝔠 and 𝔢; 𝔣 and ſ; 𝔫 and 𝔲; 𝔬 and 𝔳; 𝔯 and 𝔵; 𝔅 and 𝔙; 𝔑 and ℜ; 𝔐 and 𝔚.

THE ALPHABET OF GERMAN HANDWRITING.

Small Letters:



Capital Letters:



To facilitate the knowledge of German type, some of the following explanations in English are partly printed in German type.

THE GERMAN ALPHABET.

Each of the German vowels has but one pronunciation, varying only in length. Thus the German 𝔄, 𝔞, is *always* pronounced *as in father*, though in certain words the sound is shorter. It varies in quantity, but not in quality. The same rule is to be observed with the other simple vowels —𝔢, 𝔦, 𝔬, 𝔲.

The simple consonants are on the whole pronounced as in English, except the ℭ, 𝔠 (like *ts* in *bits*); the 𝔊, 𝔤 (like *g* in *go*); the ℜ, 𝔯, which is more rattling than in English; the 𝔙, 𝔳 (generally like *F, f*); the 𝔚, 𝔴 (like the English *V, v*); and the ℨ, 𝔷 (like *ts* in *bits*). The 𝔖, 𝔰 is pronounced sharp or soft, according to its position in the word.

The simple vowels 𝔞, 𝔬, and 𝔲 are subject to modification, this modification being indicated by ʺ above the vowel—𝔞̈, 𝔬̈, 𝔲̈. Letters thus marked are pronounced differently, and are generally used to express changes in the number, tense, degree, and volume (diminutives) of different classes of words.

The *double vowels* (with few exceptions) and the double consonants are pronounced as if they were simple, only the former long, the latter sharper. By doubling the consonant the preceding vowel becomes short.

In German all letters are pronounced, except the 𝔢 after 𝔦, and the 𝔥 after any vowel at the end of a word, or between a vowel and a consonant. In such cases the 𝔢 and 𝔥 are not to be considered, strictly speaking, as letters, but merely as signs to indicate the lengthening of the preceding vowel. Another case where the 𝔥 is not pronounced is after 𝔱, in such words as Theil (part), which is pronounced "tile"; but the practice of introducing it in this position is being gradually abandoned, so that in all modern books the word is spelt Teil.

The exact pronunciation of the whole alphabet, the principal rules, exceptions, and examples, will be found in the following tables, which the student is emphatically advised to read repeatedly, until he has completely mastered them.

TABLE I.

Latin.	German Print.	German Name.	Pronunciation.	Latin.	German Print.	German Name.	Pronunciation.
A a	𝔄 𝔞	Āh	As a in *fäther*.	N n	𝔑 𝔫	Ĕn	No difference.
B b	𝔅 𝔟	Bēh	Bay.*	O o	𝔒 𝔬	Oh	As in *short*.
C c	ℭ 𝔠	Tsēh	Tsay.*	P p	𝔓 𝔭	Pēh	Pay.*
D d	𝔇 𝔡	Dēh	Day.*	Q q	𝔔 𝔮	Kvēh or Kōō	Kvay or Koo.
E e	𝔈 𝔢	Ēh	Like the a in *fate*.	R r	ℜ 𝔯	Ĕrr	As in *berry*.
F f	𝔉 𝔣	Ĕff	As in *effort*.	S s	𝔖 ſ 𝔰†	Ĕss	No difference.
G g	𝔊 𝔤	Gēh	Gay.*	T t	𝔗 𝔱	Tēh	Tāy.*
H h	ℌ 𝔥	Hāh	The h aspirated, the a as in *fäther*	U u	𝔘 𝔲	Oo	As in *bōōt*.
I i	ℑ 𝔦	Ēe	As in *bee*.	V v	𝔙 𝔳	Fow	Ow as in *gown*.
J j	𝔍 𝔧	Yŏt	As y in *yăcht* (shorter).	W w	𝔚 𝔴	Vēh	Vay.*
K k	𝔎 𝔨	Kāh	The a as in *fäther*.	X x	𝔛 𝔵	Ĭks	Like ix in *six*.
L l	𝔏 𝔩	Ĕll	No difference.	Y y	𝔜 𝔶	Ypsēēlōn	Y like i pronounced with rounded lips.
M m	𝔐 𝔪	Ĕm	No difference.	Z z	ℨ 𝔷	Tsĕt	Ts as in *nets*.

* Remember to pronounce the vowel clearly, without sounding the slight y, which is merely used in the phonetic spelling as the nearest approach to the actual sound.

† The form 𝔰 is only used at the end of the syllable or word.

TABLE II.

Signs. Above letters and syllables ¯ when long; ˘ when short; ˙ when very short; ′ stress.

Letters.	German Name.	German word.	Pronunciation.	Translation into English.	Rules and Exceptions.
A a 𝔄 𝔞	Āh	𝔊𝔞𝔟𝔢 𝔅𝔞𝔩𝔩 ℌ𝔞𝔫𝔡	Gābĕ Băll Hănt	gift ball hand	The German A a is *always* pronounced as in the English *father* and *arm*, only sometimes long or short.
B b 𝔅 𝔟	Bēh	𝔅𝔞𝔩𝔩 𝔅𝔯𝔲𝔡𝔢𝔯 𝔊𝔯𝔞𝔟	Băll Broodĕr Grāp	ball brother grave	Beh sounds like the English b; at the end of words and prefixes like a mild p.
C c ℭ 𝔠	Tsēh	ℭ𝔢𝔡𝔢𝔯 ℭ𝔞𝔱𝔬 ℭ𝔩𝔞𝔰𝔰𝔢*	Tsāydĕr Kāhtō Klăssĕ	cedar Cato class	The words beginning with tseh are of foreign origin; pronounce like ts before e or i, like k before all other letters.
D d 𝔇 𝔡	Dēh	𝔇𝔲 𝔇𝔬𝔯𝔫 𝔅𝔞𝔫𝔡	Doo ŏ as in short Bănt	thou thorn ribbon	At the end of words like a mild t.
E e 𝔈 𝔢	Ēh	𝔈𝔫𝔤𝔩𝔞𝔫𝔡 𝔈𝔡𝔲𝔞𝔯𝔡 𝔏𝔢𝔟𝔢𝔫	Áynglănt Áydooart Lāybĕn	England Edward life	When short like e in *bet*. When long like a in *fate*.
F f 𝔉 𝔣	Eff	𝔉𝔢𝔡𝔢𝔯 𝔉𝔦𝔰𝔠𝔥	Fāydĕr Fish	feather, pen fish	The sound of f is identical in both languages.
G g 𝔊 𝔤	Gēh	𝔊𝔞𝔯𝔱𝔢𝔫 𝔊𝔢𝔟𝔢𝔫 𝔈𝔴𝔦𝔤	Gărtĕn Gāybĕn Ayvĕech (like ch in *loch*)	garden give eternal	*Always* like the g in *go*; except at end of words—like 𝔠𝔥, but less guttural.
H h ℌ 𝔥	Hāh	ℌ𝔢𝔯𝔷 ℌ𝔬𝔥𝔩 𝔖𝔱𝔯𝔬𝔥	Hărts Hōhl Shtrōh	heart hollow straw	As in English, but before consonants and at the end of words mute, to indicate the long sound of the preceding vowel.
I i ℑ 𝔦	Ee	ℑ𝔠𝔥 ℑ𝔤𝔢𝔩	Eech (softer than ch in *loch*) Eegl	I hedge-hog	I like i in *bill* when short, or like ee in *bee* when long; *never* like i in *mine*.
J j ℑ 𝔧	Yŏt	ℑ𝔞 ℑ𝔢𝔡𝔢𝔯 ℑ𝔬𝔠𝔥	Yāh Yaydĕr Yŏch (like ch in *loch*)	yes every yoke	J *always* like y in *yacht*; *never* like the j in English *jail, jaw*, etc.
K k 𝔎 𝔨	Kāh	𝔎𝔫𝔦𝔢 𝔎𝔞𝔥𝔫 𝔎𝔦𝔯𝔰𝔠𝔥𝔢	˙K-nee Kān Keershĕ	knee boat cherry	K *always* sounds as in *king*; is *never* mute as in *knee, knowledge*, etc.
L l 𝔏 𝔩	Ĕll	𝔏𝔞𝔫𝔡 𝔎𝔩𝔞𝔤𝔢 𝔉𝔞𝔩𝔩	Lănt Klāgĕ Făll	land complaint fall	L as in English, but *always* sounded; it is *never* mute in German as in *half*.

* Now generally spelt 𝔎𝔩𝔞𝔰𝔰𝔢.

TABLE II.—*continued*

Signs. Above letters and syllables ¯ when long; ˘ when short; ° when very short; ′ stress.

Letters.	German Name.	German word.	Pronunciation.	Translation into English.	Rules and Exceptions.
M m 𝔐 𝔪	Ĕm	Mann Magen Mund	Mănn Măghĕn Moont	man stomach mouth	As in English. U as in *pull*.
N n 𝔑 𝔫	Ĕn	Nagel Narr Name	Năghĕl Nărr Nămĕ	nail fool name	As in English.
O o 𝔒 𝔬	Ōh	Ohr Holz	Ōhr Hŏlts	ear wood	As in *stōne* when long, and in *pŏt* when short.
P p 𝔓 𝔭	Pēh	Pelz Politik	Pĕlts Pollytéék	fur politics	As in English.
Q q 𝔔 𝔮	Kvēh, *or* Kōō	Qual Quadrat	Kvāl Kvădrắt	pain, torment square	Q is *always* followed by u.
R r ℜ 𝔯	Ĕrr	Rabe Rolle Herr	Răbĕ Rŏllĕ Hăyrr	raven roll Mister, Sir	More rattling and better audible than the English r, especially the double rr.
S s 𝔖 𝔰 ſ	Ĕss	Salz Rose Gras	Zălts Rōzĕ Grās	salt rose grass	Before vowels like the English z; at the end of syllables and before consonants sharp, as in *slave*.
T t 𝔗 𝔱	Tēh	Tag Hut Nation	Tăch (as in *loch*) ū as in *boot* Nătsiōn	day hat nation	Before the termination ion derived from the Latin, the t is pronounced ts.
U u 𝔘 𝔲	Ōō	Uhr Buch Mutter	ūh as in *boot* ch as in *loch* Mŭttĕr	clock, watch book mother	Like o in *move* when long, and oo in *book* when short.
V v 𝔙 𝔳	Fōw	Vater Volk Vivisektion	Fāhtĕr Fŏlk Vĭvĭsĕktsiōn	father people vivisection	Like the English f, except in words of Latin origin, where the v sounds as in English.
W w 𝔚 𝔴	Vēh	Wille Bewegung	Villĕ Băyvāygŏong	will movement	Like the English v; *never* like w in *will*, *well*, etc.
X x 𝔛 𝔵	Ĭks	Axt Text	Akst Tekst	axe text	As in English.
Y y 𝔜 𝔶	Ўpsēēlŏn	Yacht Martyrium Mystik	(ch as in *loch*) Mărtēēreeōōm Mís-tik	yacht, pinnace martyrdom mysticism	Before a, o and u as in English; in all other cases like e.
Z z ℨ 𝔷	Tsĕt	Zorn Tanz	Tsŏrn Tănts	anger, wrath dance	Like ts in *feats*, *sheets*, etc., *always* sharp.

TABLE III.

Signs. Above letters and syllables ¯ when long; ˘ when short; ˙ when very short; ʹ stress.

Modified Vowels. Letters.	Modified	German word.	Pronunciation.	English Translation.	Rules and Notes.
A a	Ä ä	Ähre ängstlich Käse	Äirĕ ĕngstlēech Käizĕ	ear of corn anxious cheese	When short as e in *bet*; when long like ai in fair.
O o	Ö ö	böse Öl Tölpel	bŏzĕ Ŏl Tŏlpĕl	bad, angry oil dunce, block-head	Almost like the i in *girl* when long; and like e in *tell*, with rounded lips, when short.
U u	Ü ü	Mühle Müller grün Rübe	Mülĕ Mŭller grün Rübĕ	mill miller green turnip	As the French u long. As the French u short.
Diphthongs. Letters.	Compound				
A i a i	Ai ai	Saite Waise Hai	Zitĕ Vīzĕ Hī	string orphan shark	Like the i in *kind*.
A u a u	Au au	Auge Haus grau	g as in *go* Hows	eye house grey	Like ow in *cow*, *gown*, etc.
E i e i	Ei ei	Ei reich verzeihen	I ch as in *loch* fertsĕihĕn	egg rich to forgive	Like the i in *kind*.
E u e u	Eu eu	Eule Treue Heu	Oilĕ Troi-ĕ Hoy	owl fidelity hay	Like oi in *oil*.
Ä u ä u	Äu äu	Bräute Kräuter Gräuel	Broitĕ Kroitĕr Groi-ĕl	brides herbs horror	Like oil in *oil*.
Double Vowels.					
	Aa aa	Haar Paar Saat	 Zaat	hair pair seed	Double vowels sound like the simple vowels, but are always pronounced long. When a prefix ending with an e or o precedes a word beginning with an e or o, the two vowels must be pronounced separately, as in be-einträchtigen, be-einflussen, co-ordination, co-operation, etc.
	ee	Meer See Beere	Mäyr Zäy Bäyrĕ	sea lake berry	
	oo	Loos Boot Moor	Lohs Boht Mohr	lot, allotment boat moor	
	ii	Liniiren	Lēenēeeerĕn	to draw lines on, to rule	Very rare form. These vowels are always pronounced separately. The long i-sound, which would correspond to the aa, ee, oo, is expressed by ie.

TABLE IV.

Signs. Above letters and syllables ¯ when long; ˘ when short; ° when very short; ′ stress.

Compound Consonants.		German word.	Pronunciation.	English Translation.	Rules and Notes.
C h c h	Ch ch	Rache Herrlich Brauch Chemie China Christ Champagner	Rachĕ ch as in *loch* (*see* Notes) ch like k ch like sh	vengeance magnificent custom chemistry China Christian champagne	ch sounds as in the Scotch *loch*; after the vowels e and i and the diphthong ei it has a milder sound, also in some words of foreign origin; in other words it is pronounced like k; in some words, derived from the French, like sh.
c h s	chs	Lachs Sechs	Lăks Zĕks	salmon six	chs sounds like x, except in cases in which ch and s are put together by declension, etc.
c k	ck	Fackel Rock	Făkkĕl Rŏck	torch coat	Like a sharp and short k, used instead of kk.
P f p f	Pf pf	Kopf Pfründe	Kŏpf Pfründĕ	head prebend	In pf both consonants must be audible, though pronounced together.
P h p h	Ph ph	Phantom Philister	Phantŏ́m Philĭ́ster	phantom Philistine	Like f, as in English words of Greek origin.
P ſ p s p ſ	Pſ ps pſ	Psalm Gyps	ps as in *caps* Gĭps	Psalm plaster	The p, s and l well audible.
S c h ſ c h	Sch ſch	Schaf Tasche	Schāf Tăshĕ	sheep pocket	Like the English sh in *shave*.
S p ſ s p	Sp ſp (sp)	Spaß Splitter, Sprung Knospe, Espe	Shpāss Shplittĕr Shprŭng K-nŏspĕ, Ĕspĕ	joke, fun splinter leap bud, asp	When followed by consonants l, r, or vowels, like shp; when preceded by a vowel or between two vowels, like sp in *crisp*, *hospital*.
ſ ſ ſ z	ſſ ß ß=ſz	Masse Blaß, paſſt	Very sharp as in *gossip* and short *a* Sounds like s in *sense* and short *a*	mass, bulk pale (it) suits	ss between two vowels of which the first is short; sz at the end of some words. ss changes into sz in conjugation forms of verbs.
S t ſ t	St ſt	Stock Mast Fürst, Obst	Shtŏck Măst	stick, cane mast prince, fruits	When followed by vowels, like sht. When preceded by vowels, like st. When preceded and followed by vowels, like st. When preceded and followed by consonants r, b, like st.
T h t h	Th th	That rathen	Tāt Rāthĕn	deed, action (to) advise	Always like t; *never* like the English th.
T z t z	Tz tz=zz	Gesetz Tatze	Găyzĕts Tătsĕ	law claw, paw	Sharper than ts in *sheets*. Used instead of zz.
Double Consonants. ff, ck (kk), ll, mm, nn, pp, rr, ſſ, tt, (zz).		Affe, Hölle Kamm, Mann Rippe, Narr Essen, Kette		monkey, hell comb, man rib, fool (to) eat, chain	The double consonants short and sharp.

Beware of pronouncing:

A, a any other way than in *father* (though the sound is at times shorter);

C, c any other way than *ts* in *hats* (except before a, o, and u, when it is pronounced like a k, by which it is now generally replaced);

G, g any other way than in *go*;

I, i any other way than in *bit* (short) and *bee* (long);

Th, th any other way than *t*;

V, v any other way than *F, f* (except in words of Latin origin);

W, w any other way than *V, v*;

Z, z any other way than *ts* in *bits*.

Beware of suppressing, in the pronunciation of words, the letters k, l, and w, which are sometimes mute in English (*knowledge, folk, who*). Mute in German are only the h and e, when used as a means of lengthening the syllable.

Lesson I.

1. How do you pronounce the German I, i ?
2. What is the difference between the English and the German pronunciation of the *th* ?
3. How is the German b pronounced at the beginning and at the end of a word ?
4. Which general rule decides the pronunciation of German vowels ?
5. Is the pronunciation of the *r* alike in German and English ?
6. In how many ways can the German a be pronounced ?
7. Is there a similar sound to the German compound ch in the English language ?
8. How is the German s influenced by the preceding vowels or consonants ? Does the sound of the German s differ according to the position of the letter at the end or in the middle of syllables or words ?
9. To which English sounds does the German c and z bear resemblance ?
10. Is it permissible to pronounce German words containing a w as it is done in *well, will*, etc.
11. To which letter in the English alphabet does the German v correspond ?
12. Which German letters are sometimes mute, and what purpose do they serve ?
13. How is the sound of the German ü produced ?
14. With which English letter does the pronunciation of the German ê correspond, and in which word is the English letter thus pronounced ?
15. How many classes of vowels does the German language contain ?
16. Are the compound consonants always pronounced in the same way ?
17. Which is the pronunciation of the compound consonant sp, when followed by a consonant ?
18. Is there any difference between the pronunciation of the English *f* and the German ?
19. Does the German compound consonant ch always keep its pronunciation, or is it subject to alterations ?
20. Which is the pronunciation of the German ch when followed by s and when preceded by s ?

Examples of Lesson I.

1. Bild, picture ; Insel, isle ; Winter, winter.
2. Thee, tea ; Thron, throne ; Thurm, tower.
3. Bank, bench, bank ; Bibel, bible ; grob, coarse, rude.
4. Mann, man ; Magen, stomach ; Welt, world ; geben, (to) give ; Esel, donkey ; Lippe, lip ; Sieg, victory ; wir, we ; Gott, God ; Bote, messenger ; kurz, short ; gut, good.
5. Ring, ring ; hart, hard ; hurtig, quick ; Trommel, drum.
6. Maler, painter ; Mast, mast.
7. Loch, hole ; lachen, to laugh.
8. Sonne, sun ; Besitz, property ; Gans, goose.
9. Capital, capital ; Citrone, lemon ; Clavier, piano.
10. Wagen, carriage ; Wolf, wolf ; wir, we.
11. Veilchen, violet ; Verachtung, contempt ; Ventil, valve.
12. Muhme, cousin ; Liebe, love.
13. Kühe, cows ; Thüre, door.
14. Hörner, horns ; Hölle, hell ; König, king.
15. Land, land ; Berg, mountain ; Wild, game ; Kohle, coal ; Mund, mouth ; Bär, bear ; Getöse, noise, din ; Türke, Turk ; Laib, loaf ; Thau, dew ; Eis, ice ; neu, new ; Häuer, cutter, miner ; Aal, eel ; Speer, spear ; Boot, boat.
16. Stark, strong ; Obst, fruit ; Ast, branch ; Horst, eyrie, thicket ; Gestalt, figure.
17. Sprache, language ; Spritze, syringe ; spleißen, to split, to cleave.
18. Jagd, chase, hunting ; Jammer, lamentation ; bejahrt, aged.
19. Drache, dragon ; Fächer, fan ; Nachricht, intelligence, report, news ; Orchester, orchestra ; Chef, chief ; Chor, chorus, choir ; Chocolade, chocolate.
20. Fuchs, fox ; Ochs, ox ; Sachse, Saxon ; Mischung, mixture ; Wäsche, washing.

To be continued

Note. A second lesson of the French Course appears in Part 3 of the Self-Educator

Group 1
AGRICULTURE
2

THE SOIL AND ITS CULTIVATION

Soils; their Constitution and Values. How to Understand Them. Their Fertility. Treatment of Bad Soil

By Professor JAMES LONG

IF it were possible to remove the surface and subsoil of a field perfectly, we should probably expose the rocks from which both have been produced. Both soil and subsoil are practically formed by the weathering and disintegration of the rocky surface of the earth. It is true that much cultivated soil owes its presence to glacial action or to the fact that it has been deposited by water, and this especially marks the fertile *alluvial* soils (soils which have collected by the action of running water), which are so frequently found in valleys and adjacent to rivers. The cultivated soil of to-day is, however, something more than pulverised rock. It contains *humus*—decomposed vegetable matter—which is largely the result of the work of man. The decayed roots of plants and farm manure all assist in the accumulation of humus, the value of which it is difficult to overestimate.

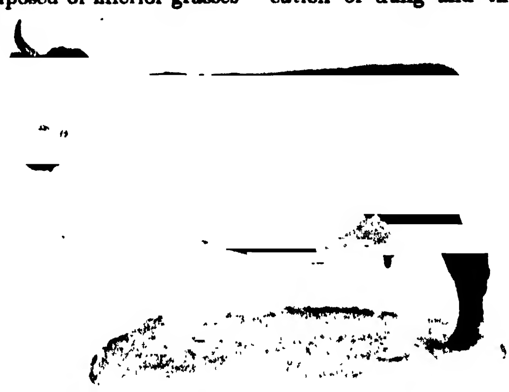
Depth of Soil. A soil may vary from 3 inches, especially on chalky downs, to 14 or even 15 inches in depth. Were it possible for the plough to do its work still further below the surface, the depth might be increased, and with great advantage. On many farms, however, the plough has never penetrated more than 10 ins., with the result that what is termed a hard "pan" is formed, through which plant roots penetrate and water percolates with difficulty. The decomposition of the subsoil, as of rock, depends upon the action of air, water, and heat. If we take a piece of hard tenacious clay or a lump of chalk, and expose it to the action of frost, we find after a thaw that it has been reduced to powder. Similarly, during summer, clay and other heavy soils laid up in ridges by the plough, dried by the sun, and wetted by rain, are so weathered that they break up, if not equally as fine, yet to the great benefit of the farmer. So it is in minor degree with the rock substances beneath; hence, the importance of deep cultivation, as of trenching or double digging in the garden, the surface soil being always kept at the top, and hence, too, the service rendered to man by the earth worms in constructing channels in all directions, and thus enabling air and water to find their way below.

The Perfect Soil. A perfect soil is one which consists of nearly equal quantities by volume of clay soil, sandy soil, chalky or calcareous soil, and vegetable soil rich in humus, and which is composed of finely divided particles. A good soil contains from 50 to 60 per cent. of sand; from 25 to 30 per cent. of clay; with pulverised limestone or chalk, and humus, each about 7 to 10 per cent.; sand, clay, and humus, usually represent about 90 per cent. of an average fertile soil. The soil contains both soluble and insoluble materials. The soluble portions are those of which plants make use in building up their structure; portions of the soluble matter are, however, commonly lost by drainage, and here we see the important part which is played by water, which is a large constituent of all soils, varying in quantity with their character, the climate, and the season. Plants are unable to utilise solid materials; the food they take up must be in solution. Water derives its power to dissolve soil substances, not only from the carbonic acid which is liberated in the soil by the decomposition of humus, but by that with which it is charged when falling in the form of rain.

Variations in Colour. Soils differ in colour owing to the presence of minerals, as *oxide of iron*, an oxide being a compound of oxygen and a substance which combines with it, and which imparts to it a red tint, while it differs in mechanical texture and character, owing to the fact that it is the product of different forms of rock, as limestone, granite, red sandstone, slate, or clay. Soil is termed heavy when it is chiefly composed of clay, and cold when the clay, more or less pure, comes close to the surface. A clay soil is a soil which contains over 50 per cent. of clay. A loam, which is regarded as a free, open, kind, and mellow soil, contains from 25 to 30 per cent. of clay, a clay loam coming between the two, and covering a clay subsoil; a sandy loam contains less than 25 per cent. of clay, and a sandy soil fit for cultivation less than 10 per cent. of clay. Soils over limestone or chalk with more than 20 per cent. of either are regarded as calcareous.

The four materials, clay, sand, limestone or chalk, and vegetable matter or humus, are essential to all soils. The clay provides tenacity and water-retaining power. The sand provides for the admission and percolation of water and air, as well as for free working and warmth. Limestone, or chalk, when pulverised, adds other important properties. It supplies a plant food, it neutralises acids, it attracts moisture, it improves the texture of the soil, and assists in the decomposition of materials which are intended as foods for plants, especially aiding, as we shall see later, in the process of *nitrification* (the chemical change resulting from the activity of soil organisms, of the nitrogen of humus into nitric acid). The vegetable matter of a soil assists in the retention of moisture. As it decomposes, it imparts warmth to the soil, and provides carbonic acid—which, as we have seen, enables water to dissolve certain necessary soil constituents—together with ammonia, which in its turn supplies plant life with nitrogen (the element forming $\frac{4}{5}$ths of the atmosphere).

How to Judge the Value of a Soil. The expert is usually able to value land from its colour, its texture, the depth of the surface soil, and the plants which grow upon it, from weeds to timber trees. If we select a field, and with a spade dig a few feet deep, we should not only be able to ascertain the approximate depth of the surface soil, but of the under, or subsoil, and possibly to reach the hard rock beneath. A good soil, from the farmer's point of view, is deep, of rich dark colour, such as brown or red, the pastures are thick, growing abundant clover, the woods and hedgerows strong and healthy, and the weeds, like the cultivated crops, vigorous and robust. Good land, too, should slope towards the south, and be well drained and provided with water for stock, but water should never lie on the surface. On the contrary, inferior land is that which is wet, with a thin or spongy surface soil, or which produces weak, poor crops, deficient clover in the pastures, and weeds and trees which indicate its second-rate character. Where pastures are largely composed of inferior grasses and such weeds as *couch*, or twitch (a grassy weed, *Triticum repens*), and especially where moss is prevalent, they may be regarded as either extremely poor in condition or naturally inferior. Bad land is also indicated by the presence of heather and bracken, rush and sedge, beech and fir; excessive water contributes to its sourness, and absence of humus to its poverty and physical insufficiency.



MR. M. J. SUTTON'S PRIZE DEXTER COW, IRISINE

Method of Comparison. The difference between a poor soil, especially one chiefly composed of sand, chalk, or gravel, and a rich soil, such as that of an old garden, may be readily ascertained in the following way. A given weight of each should be taken, carefully weighed, and dried until the weight remains constant, until, in fact, the whole of the moisture has been driven off. If now weighed, the loss sustained will represent the water contents. If we now burn the dry soil remaining with equal care, and again weigh the residue, the difference between the dry matter submitted to ignition and that remaining will represent the organic matter of the soil, practically consisting of humus. The unburnt ash represents the inorganic or mineral proportion.

We have seen that water plays an important part in the formation of soils and in the conveyance of soluble matter to the plant; it does something more; by its action upon the surface, especially where that surface is uneven, it removes or washes away the finer portions as, for example, during rain, and enables them to collect, as may be noticed on the lower side of a road, or in the furrows of an arable field. Some of the richest soils are those known as alluvial, which have been deposited practically as they are by water. We may take another example of a water-deposited soil from the warping of land in Lincolnshire. As the Humber rises, its water is flooded over land which has been selected for improvement, and allowed to remain at rest until it has deposited the fine particles of soil which it holds in suspension. In this way, by repeated floodings, a foot of *alluvium* may cover the surface, and thus immensely add to the value of the land and its crop-bearing character. Thus, water may not only contain matter in solution, but matter in suspension.

Fertility. In the practice of farming, matter essential to the growth and life of plants is removed in the crops which are harvested and carried away. This fertility is renewed in various ways; by the decay of the organic matter within the soil,—as animal manure, and the roots of plants; by the application of dung and the artificial or chemical fertilisers; by the ammonia brought down in the rain; by the weathering of the subsoil which follows deeper ploughing, stirring, or sub-soiling; and, where *leguminous* plants (plants of the order *Leguminosæ*) are grown, by the aid of the nitrogen which, under given conditions, they are able to extract from the atmosphere; and, lastly, as regards pasture land, by the aid of the droppings, both liquid and solid, of highly-fed animals. Fertility not only depends upon the presence of plant food in an available condition, but on sufficient moisture and on the bacteria (very minute organisms), which are essential to *nitrification*. These organisms, which require moisture, air, and heat—hence the greater rapidity of nitrification in summer—decompose organic matter, the nitrogen of which, being converted into nitric acid, unites with a base, such as *carbonate of lime* (a compound of carbonic acid and a base), and thus forms a combination of which the roots of plants can make use.

Again, the *bacteria* responsible for the collection of atmospheric nitrogen are essential, that this element may be supplied to the leguminous herbage, clover, beans, peas, and vetches, among others. Their presence is denoted by the tiny nodules which will be found on the roots of these plants.

How Plants are Fed. Only a small proportion of the food of plants, or of the materials of which they are composed, is obtained from the soil. In all, there are some 15 of the chemical

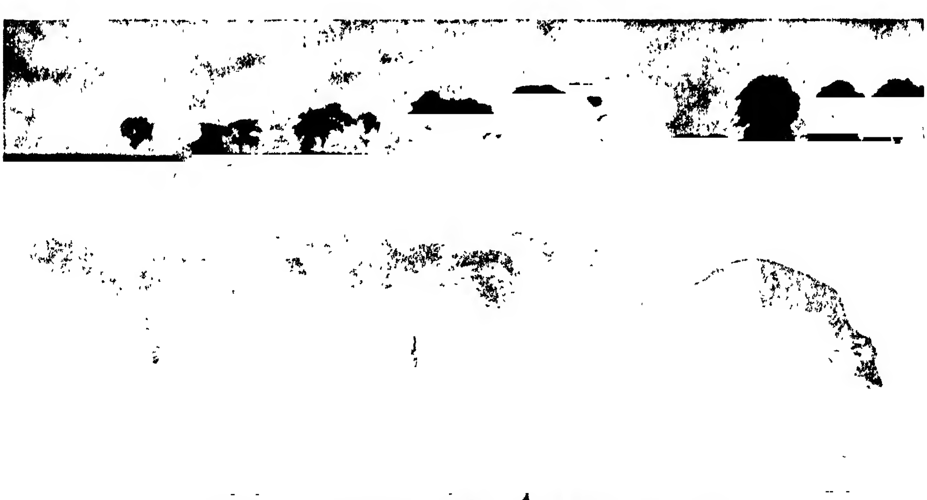
elements which are closely related to plant life. They include carbon, oxygen, nitrogen, hydrogen, and sulphur, all of which are combustible, and the minerals phosphorus, potassium, calcium, magnesium, sodium, and iron, all of which are essential. Of these the most important to the farmer are nitrogen, potassium, phosphorus, as phosphoric acid, and calcium (an alkaline earth metal), as lime, all of which it is necessary to supply with some frequency to old cultivated soils, as the supplies become exhausted, owing to the fact that they frequently run short, being utilised by plants more quickly than they are provided by Nature. That the materials named are present in plants can be proved by analysis, the mineral matter of soil being found in its ash after burning. The chief constituent of plant life is carbon, of which it is estimated that 3½ volumes exist in every 10,000, and that 28 tons, as carbonic acid, or carbon dioxide, are present in the air over every acre of land. Oxygen, which forms about one-fifth of the atmosphere, comes next in order, and of this it has been calculated that 21,000,000 lbs. are over every acre of land.

LINCOLN RAM: A CHAMPION AT THE ROYAL SHOW

Constituents of Soils. Brief reference may now be made to some of the chief materials found in soil. Clay is chiefly composed of silica and aluminium. It is seldom pure, but is tenacious, resisting the passage of water and of air; it is cold when wet, but liable to bake hard in summer. It has the property of retaining the most valuable constituents of both animal and artificial manure. Clay land is often termed season land, owing to the fact that it can only be cultivated under opportune conditions.

Sand is useless for crop-growing, owing to its want of tenacity, its inability to retain water, its destitution of organic matter and plant food, and its great warmth in summer. Just as clay needs sand and humus to improve its texture, so does sand need humus and clay to make it homogeneous, fertile, and able to retain water.

Effect of Lime on the Soil. A calcareous soil, whether over limestone or chalk calcium carbonate, is usually deficient in both organic matter and clay, while at the same time it may be excessively rich in carbonate of lime, which, when burnt, produces oxide of lime or quicklime, one of the most valuable aids to farming. Lime sweetens a sour soil by neutralising its acids; it assists in the retention of moisture, and in the improvement of texture. It enters into the composition of plants, and thus assists in the formation of the bones of animals; it further aids in the decom-



MR. W. R. FLOWER'S DORSET HORN SHEARLING EWES

position of organic matter, liberating nitrogen compounds, and by its action upon clay and other mineral constituents of the subsoil it provides a supply of potash.

How Soils are Improved. The improvement of soil is effected partly by Nature and partly by man. Improvement depends upon the addition of materials which provide food for plants, and which modify their texture as well as upon methods of cultivation, such as ploughing, cultivating, harrowing, rolling, and draining. In dry weather the surface of a field may be exceptionally dry, and even capped with a thin crust. This is chiefly owing to the evaporation of moisture. If this cap is broken by a sharp-toothed harrow or by the cultivator, water is induced to travel upwards from below, and to supply growing plants; hence the practice of stirring with the horse-hoe between the rows of roots, cabbage, or potatoes, or of harrowing a young plant of wheat in early spring. Where a *pan* exists, below which the plough has not penetrated, the upward movement of water is checked. Stirring often and deep is essential in good farming.

The movement of soil water is imperative in order that it may convey to plants the soluble materials of which they are in need. This movement is aided by artificial drainage where natural drainage does not exist; hence the importance of draining heavy clays and soils in which water is stagnant. Rain water adds nitrogen to soil, which, in the form of nitric acid and ammonia, it takes up in its passage through the atmosphere, but this important contribution of nature is of little avail, if, owing to want of drainage, a soil is impermeable, cold, and its water-table high, or, in other words, where water rests stagnant near the surface.

Restoring the Balance. Soils which contain an excess of one constituent, as clay, sand, gravel, peat, or chalk, are improved only by the addition of such materials, and by such a form of cultivation as will bring them approximately to the condition of loam. Long manure—*i.e.*, dung containing plenty of straw—sand, road scrapings, and chalk reduce the tenacity of clay, assist in making it pervious to air and water, raise its temperature, and make it less difficult to till. Sand and other light soils are improved by the addition of short manure—the produce of cows and pigs—by clay and by marl—a form of clay more or less rich in carbonate of lime. Such soils are thus made more homogeneous, compact, and tenacious; they hold water better, retain soluble plant food more perfectly, and are less liable to starve growing plants. A chalky soil, which is frequently thin, is equally improved by the addition of clay and heavy dung. One of the best methods, however, of increasing its fertility is that of growing turnips, sainfoin, and clover, by the aid of acid phosphatic manures, that they may be consumed by sheep which are folded upon them, and which are simultaneously supplied with rich foods such as cake and corn. Soils of a peaty character, which are usually sour, and sometimes a mass of spongy vegetable matter, are immensely improved by the aid of lime or chalk.

LEICESTER SHEARLING RAM

CHAMPION DARTMOOR RAM

Where peaty soils can be cultivated by the plough, liming or chalking may be followed by the employment of phosphates and potash salts, sown with vetches, clover, or some similarly suitable leguminous plant, with or without ryegrass, rye, or oats, and so prepared for potatoes and other suitable crops. There are, however, so many variations in soils of this character that the grower should observe what has been accomplished in the practice of his neighbours. The paring and burning of soil, whether with the object of destroying weeds or improving its texture, is not to be recommended. The nitrogen of a soil is principally found within nine inches of its surface; burning, therefore, is followed by a serious loss of this valuable constituent.

One of the most important methods of improving soils of extreme texture, such as clay or sand, is, as already mentioned, of ploughing-in green crops, such as mustard, rape, or vetches, to which the Germans add lupins with great success. These crops grown by the aid of potash salts and phosphate of lime, not only increase the percentage of humus or organic matter, but add nitrogen and carbonic acid.

To be continued

SHORTHAND

Second Instalment of the Special Course of Shorthand Taught by Sir Isaac Pitman & Sons on their Twentieth Century Plan

FOR the complete representation of words in shorthand there must be not only signs for the consonant sounds, as already explained, but also characters for the representation of the vowel sounds. The consonants form, as it were, the skeleton, while the vowels may be compared to the softer portions of the body. For example, the consonant characters represent merely two hard consonant sounds *chay, kay*, but if we add the soft vowel sound of long ē thus we get the shorthand representation of the word *check*.

Grammarians when dealing with the ordinary longhand alphabet inform us that "The vowels are *a, e, i, o, u*, and sometimes *w* and *y*." But these letters are quite inadequate for the indication of the twelve broad typical vowel sounds which are heard in the pronunciation of English words, and hence in Pitman's Shorthand four scales of signs, containing three each, are employed for the representation respectively of six long and six short vowel sounds. This method of dealing with the vowel sounds has a greater element of novelty than the consonant portion of the phonographic alphabet, but ability to detect the correct vowel sounds which are heard in any word will be gained after a little practice. It is absolutely necessary that the entire list of vowels should be thoroughly memorized.

Long Vowels. The six long vowels are as follow:

AH, EH, EE, AW, OH, OO,
as heard in the words
Alms, Ale, Eel, All, Oak, Ooze.

They should be pronounced as single sounds; thus, *ah* as in *alms* [not *a-aitch*]; *eh* as in *ape*; *ee* as in *eel*; *aw* as *awe* [not *a-double-you*]; *oh* as *owe*; *oo* as in *ooze*. They may be remembered by repeating the following sentence:

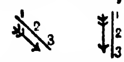
Pa may we all go too.
ah, eh, ee, aw, oh, oo.

The dots and dashes, representing the long vowels are numbered 1, 2, and 3, thus:

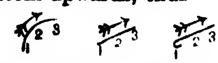
1. *ah* 1. *aw*
2. *eh* 2. *oh*
3. *ee* 3. *oo*

They are hence called *first-place, second-place,* and *third-place vowels* respectively.

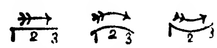
There are three distinct positions at the side of each consonant where the respective vowel signs may be placed, namely, at the beginning, the middle, and the end. These places are also numbered 1, 2, and 3. They are counted from the point where the consonant begins. In the case of down-strokes, the vowel places count from the top downwards, thus



In the case of up-strokes, the vowel places count from the bottom upwards, thus

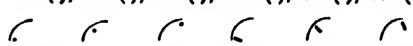


In the case of horizontal strokes from left to right, thus



The vowel signs are put in the places which correspond with their numbers; thus

tah (1), *teh* (2), *tea* (3), *taw* (1), *toe* (2), *too* (3);



lah (1), *lay* (2), *lee* (3), *law* (1), *low* (2), *loo* (3).

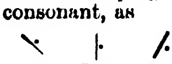
The vowel signs must be written at a little distance from the consonant. If allowed to touch (except in a few cases which will be mentioned hereafter), they would give rise to mistakes. A dash vowel may be written at any angle that is distinct, the right angle being generally most convenient; thus

or *two;* or *foe;* or *Joe.*

When a vowel is placed on the left-hand side of a perpendicular or sloping consonant, it is read *before* the consonant, as

ape, ate, age.

When a vowel is placed on the right-hand side of a perpendicular or sloping consonant, it is read *after* the consonant, as

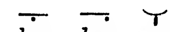


pay, Tay, jay.

When a vowel is placed above a horizontal consonant, it is read *before* the consonant, as

ache, eke, own.

When a vowel is placed below a horizontal consonant it is read *after* the consonant, as

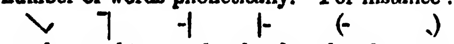


kay, key, no.

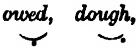
The best way to learn the vowels will be to repeat each one both before and after a consonant, in this manner:

aht ate eet awt oat oot tah teh tee taw toe too

and so on with the other consonants. In doing this the student will familiarise himself with the vowels that are strange to him, namely *ah*, *aw*, and *oo*, and discover the way to write a great number of words phonetically. For instance :



pooh, *ought*, *owed*, *dough*, *though*, *ooze*,

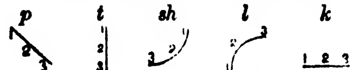


neigh, *knee*,

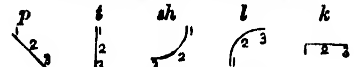
are written phonetically. In order to arrive at the correct vowel sound of any word the student must, until proficient, run over the scale of vowels till he has determined which is the one he requires.

The following diagrams further illustrate the positions of the vowels.

A VOWEL BEFORE A CONSONANT.

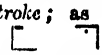


A VOWEL AFTER A CONSONANT.



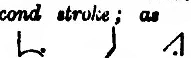
In writing shorthand the student should strike the consonant first, and then fill in the vowel in the proper place.

Long vowels between two consonants. FIRST and SECOND-PLACE long vowels, when occurring between two consonants, are written *after the first stroke;* as



talk, *gate*.

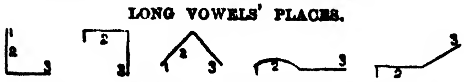
But in order to avoid an awkward position for the sign, THIRD-PLACE vowels are written *before the second stroke;* as



team, *teach*, *read*.

The vowel is still in the third-place, as indicated in the following diagram :

LONG VOWELS' PLACES.



Short Vowels. In addition to the six long vowel sounds, there are six corresponding short vowel sounds in English, which are heard respectively in the words

păt, *pĕt*, *pĭt* ; *nŏt*, *nŭt*, *fŏŏt*.

The correspondence between long and short vowels is shown as under :

The short sound of *ah* in *palm* is *a* (say *ah* quickly) in *pat*.

The short sound of *eh* in *pate* is *e* (say *eh* quickly) in *pet*.

The short sound of *ee* in *peat* is *i* (say *ee* quickly) in *pit*.

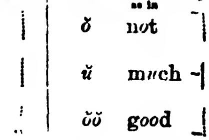
The short sound of *aw* in *nought* is *o* (say *aw* quickly) in *not*.

The short sound of *oh* in *note* is nearly *u* (*uh*) in *nut*.

The short sound of *oo* in *food* (say *oo* quickly) is *ŏŏ* in *foot*.

By *drawling* a word containing a short vowel, the corresponding long vowel will be heard. Compare *pick*, *peek* ; *cot*, *caught*.

Similar signs are employed for the short as for the long vowels, namely, dots and dashes; but the signs for the short vowels are written lightly, in order to indicate their short and lighter sound, thus :

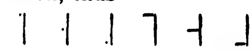


Sound	as in	Sign	Sound	as in	Sign
ă	that		ŏ	not	
ĕ	pen		ŭ	much	
ĭ	is		ŏŏ	good	

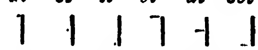
The order of the short vowels may be remembered by saying the following sentence :

That pen is not much good.

The student will find the exact value of the short vowels by pronouncing each in conjunction with a following consonant. In order to gain familiarity with them, he should write them before the different consonants, and pronounce the combination, thus

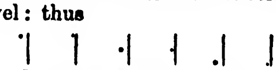


at *et* *it* *ot* *ut* *ŏŏt*

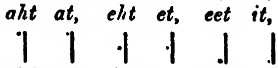


ad *ed* *id* *od* *ud* *ŏŏd*

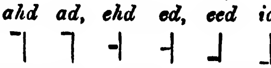
and so on with other consonants from *p* to *r* (down). When he has done this, he should contrast each short vowel with its corresponding long vowel : thus



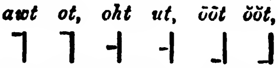
aht *at*, *eht* *et*, *eet* *it*,



ahd *ad*, *ehd* *ed*, *eed* *id*,

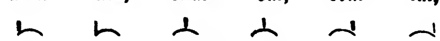


awt *ot*, *oht* *ut*, *ōōt* *ŏŏt*,



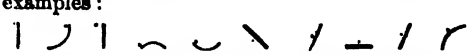
awd *od*, *ohd* *ud*, *ōōd* *ŏŏd*.

ahm *am*, *ehm* *em*, *eem* *im*,

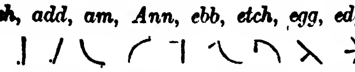


awm *om*, *ohm* *um*, *ōōm* *ŏŏm*.

As a result of this practice, many common words will be made, of which the following are examples :



at, *ash*, *add*, *am*, *Ann*, *ebb*, *etch*, *egg*, *edge*, *ell*,



it, *itch*, *if*, *ill*, *odd*, *off*, *or*, *up*, *us*.

Short Vowels between two consonants. FIRST and THIRD-PLACE short vowels are written in the same position as their corresponding long vowels ; as

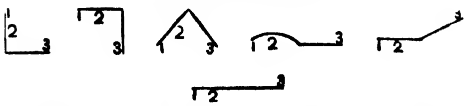
tack, tick, pap, pip, rock, rook.

SECOND-PLACE short vowels are written *before the second consonant;* as

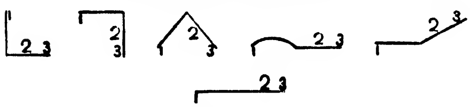
get, wreck, butt, tub, gull, lug.

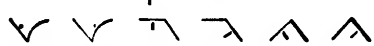
Compare the places of second-place long and short vowels in the following diagrams and words:

SECOND-PLACE LONG VOWELS AFTER THE FIRST CONSONANT.

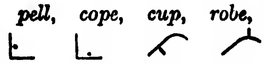


SECOND-PLACE SHORT VOWELS BEFORE THE SECOND CONSONANT.





pale, pell, cope, cup, robe, rub,



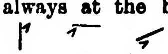
take, Teck, roam, rum.

Diphthongs. There are four double vowels, or diphthongs, namely, ī, *ow, oi, ū,* as heard in the words *vie, vow, boy* and *due.* The first three are represented by a small acute angle, and the fourth by a small semicircle, thus

I OW OI U

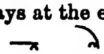
The triphthong *wī*, as heard in *wife*, is represented by a small right angle, thus WI

The diphthong *oi* is written in the first-place, and therefore always at the beginning of a stroke, as



toy, coy, Roy.

The diphthong ū is written in the third-place, and therefore always at the end of a stroke, as

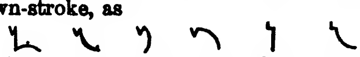


cue, your.

The diphthongs ī and *ow* and the triphthong *wī* may be written either in first, second, or third-place, as is most convenient, as

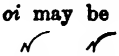
isle, tile, fowl, vowel, twibill.

Both ī and *wī* may be joined initially to a down-stroke, as



item, ivy, ice, ire; white, wife.

Both *ow* and *oi* may be joined initially to upward *l*, as



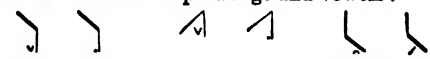
owl, oil.

Both *ow* and ū may be joined finally to a downstroke, as

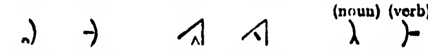
bough, vow, pew, due.

After the consonant *n*, the diphthong *u* may be written thus, *new*, and *ow* thus, *now;* ī is joined to *n* thus, *nigh.*

Learners sometimes confuse the diphthong ī with the short vowel ĭ; also ū with the short vowel ŭ, and *ow* with the long vowel *oh.* The following pairs of words illustrate the contrast between diphthongs and vowels:

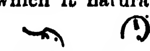


bite, bit; right, writ; tube, tub;
(noun) (verb)



use, us; rout wrote; sow, sow.

When a diphthong and vowel, or two vowels occur between two stroke consonants, each should, if convenient, be placed against the consonant to which it naturally belongs; thus,



newer, Louisa.

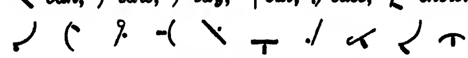
All the shorthand examples in this lesson should be carefully copied out.

EXERCISE.

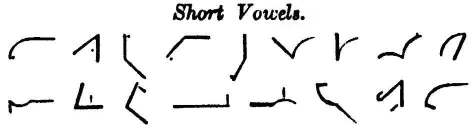
Write the shorthand form and place the longhand translation after it, as in the first line.

Long Vowels.

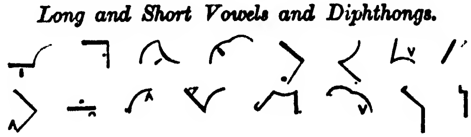
bah, saw, say, oat, ease, chew.



Short Vowels.



Long and Short Vowels and Diphthongs.



Write the shorthand word after the longhand in the following words.

The student is directed by a small capital letter when to write the letters L, R *and* H *downward.*

They, caw, awl, page, thief, HAWK, jeeR, folk, doom, dub, lad, yawL, bullock, mug, animal, mighty, loud, allow, HEW, wideR, envoy, Elijah, China, loyal, hope, value, Johnny, bunch, name, meadow, refuge, shook, notch, aRgue, attack, veal, shoRe, canaL, widow, gulf, farm, fury, tide, shaRe, naiL, HOY, manage, boy.

[A Key to the above exercise will appear in the next lesson.]

To be continued

Group 11
CIVIL ENGINEERING
2

HOW TO USE SURVEYING INSTRUMENTS

Dealing with the Chain, Optical Square, Cross Staff Head, Box Sextant, Prismatic Compass, Vernier, and Transit Theodolite

By Professor HENRY ROBINSON

THE simplest form of survey is that carried out by means of the chain. The chain usually employed is "Gunter's" chain [1]. It is 66 feet long, divided into 100 equal parts which are called links, each link therefore is 7·92 inches long. Every ten links are indicated by brass tags. The centre, or 50 link, tag is circular in shape, and is generally larger and more conspicuous than the others. At ten links' distance from each side of the 50 link tag are tags with four teeth denoting 40 and 60 links (according to the direction of the chaining). Following these are three-teeth tags, denoting 30 and 70 links, and in their proper places tags carrying two teeth and one tooth, and marking 20 or 80 links, and 10 or 90 links respectively.

1. GUNTER'S CHAIN

The advantages of a 66 feet chain are that it bears the following relations to the standards of measurements in this country:

Statute Mile	=	1,760 yards = 5,280 feet.
,,	=	80 chains (of 66 feet).
,,	=	8 furlongs.
1 Square Mile	=	6400 square chains.
1 Acre	=	10 square chains.
,,	=	100,000 square links.
,,	=	4,840 square yards.
,,	=	4 roods (1,210 sq. yards each).
,,	=	160 perches.

The chain is thus a decimal part of an acre or mile, and this facilitates calculations.

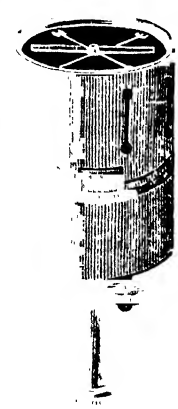
The usual accompaniments of a chain are 10 arrows (or pins) made of iron or steel, which are pointed at one end and have a ring at the other, to each of which is tied a piece of red cloth to make it clearly visible from a distance.

2. CROSS STAFF HEAD
Octagonal

Before surveying, the chain should always be tested, as it is liable to stretch with constant use.

Chaining a Line. In chaining a line (the direction of which is indicated by poles, or ranging rods), the man in front, who is usually called the leader, takes the ten arrows, and on being ranged in line by the man behind (or follower), he inserts one arrow into the ground and then proceeds for the next chain, the follower collecting these arrows as he goes on. The leader can greatly facilitate the speed of the chaining if he approximately takes up his position in the line by ranging himself by means of the previous arrow and the back pole. Some system of signals should be arranged between chainmen, that they may know in which direction to move. To prevent errors in long lines, it is usual at the end of the 10 chains (or after the whole of the arrows have been used) to cut a *station* in the ground. All the arrows are then taken by the leader. This means, that in the event of an error being made owing to the loss of a pin, or for any reason, it is only necessary to go back to the last 10 chain *station*, or *tally* as it is called.

The positions of any points to be surveyed are fixed by means of an offset staff, which is 10 links in length, each link being visible by difference of colour on the pole. The position is fixed by a right angle being set up (by the eye) from the chain line, and the distance to the point is measured with the offset staff. If there are two or more points to be taken on this offset, as, for instance, where two sides of a path are being measured, it is usual to enter the distances separately with a plus sign between them, thus: 30 + 15. In this case 30 shows the distance of the nearest point of the path from the chain line, and 15 is the width of the path. These offsets are limited as to distance on account of the inaccuracies that arise if a series of offset measurements are taken with the eye alone to preserve the continuity of the perpendicular. If offsets of any length are required, some form of instrument should be employed, as the *cross staff* or *optical square.*



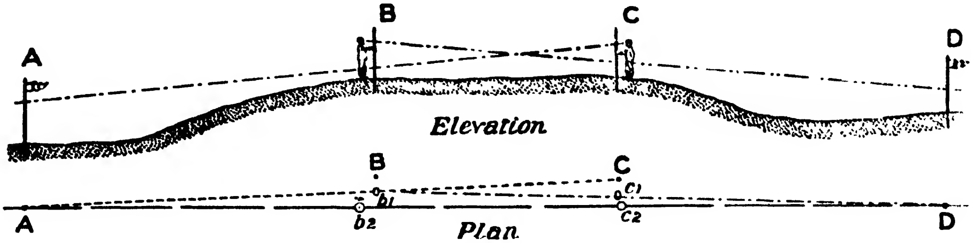
3. CROSS STAFF HEAD
Cylindrical

Cross Staff Heads. A simple form of the cross staff head can be made from a cylindrical piece of wood about four inches long and three inches in diameter, having two fine diametrical saw cuts at right angles to each other and about three inches deep. This is generally fixed to the top of an old ranging rod.

Fig. 2 shows an octagonal form of cross staff head. On

each of four rectangular sides of the octagon are plain sight slits, the remaining alternate sides having sight slits and rectangular slots with vertical hairs.

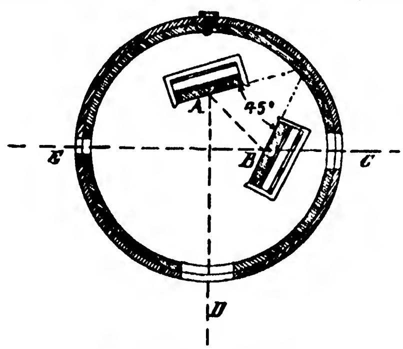
The adjustable cross staff [3] is another form of this instrument. It is more useful than those at B and C [5], so that they can respectively see the posts D and A. Operator C ranges B in line with A, making the line Cb_1A on the plan. Operator B then ranges C in line with D, making the line Bc_1D. This operation is repeated until all the four posts are



5. DOUBLE RANGING

just described, as it is possible to read angles, or take *bearings*, with it. It is cylindrical in form, divided into two parts, as shown by the illustration. The upper portion centring on the lower portion carries a vernier and a compass. The lower part has a grand circle divided into degrees. The vernier is revolved round the grand circle by the screw. The slotting for the upper portion is similar to that of the instrument described above, the lower portion having four slots diametrically opposite each other.

Optical Square. This is a small hand instrument used for setting out right angles. The optical construction is the same as that of the box sextant, only the mirror glasses A and B [4] are permanently fixed with their faces at an angle of 45° to each other, which gives a reflection of 90°. The sighting, or observation hole, E, is diametrically opposite the vision hole C. The glass B has the upper portion silvered (the lower being clear) to receive the reflection thrown by the mirror A. Sighting through the clear portion of the glass B along a chain line having the direction EBC, an object at right angles to the line of direct vision will be reflected by the mirror A on to the silvered portion of the glass B.



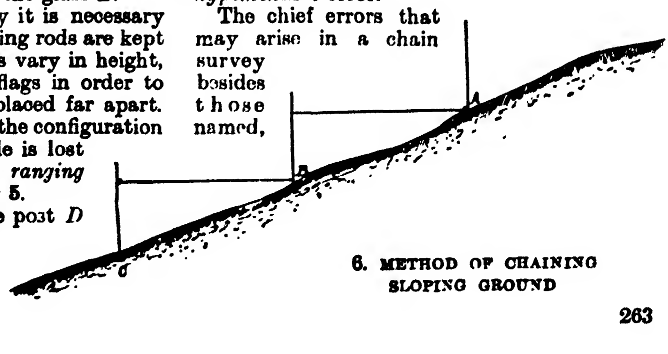
4. OPTICAL SQUARE

In ranging lines for a survey it is necessary to be very careful that the ranging rods are kept absolutely vertical. These rods vary in height, and should be mounted with flags in order to catch the eye when they are placed far apart. It often happens that, owing to the configuration of the ground, the forward pole is lost sight of. To meet this, *double ranging* has to be adopted, as shown by 5.

It being impossible to see the post D from A, owing to the rising ground intervening, two men take up intermediate positions in line, as shown by the line Ab_2c_2D on the plan.

At the ends of all survey lines, and at intermediate positions where other lines join, *stations* should be cut and a note of the chainage, etc., recorded on a piece of paper put in the hole. If the survey is to extend over any length of time, square-headed pegs should be driven into the ground, in order to enable the points to be picked up afterwards. When the ground is irregular, the chaining may frequently have to be done in short lengths, in order to get the true horizontal distance from point to point. This is usually done by bringing the point up to a ranging rod held truly vertical, and then by starting from the point thus found on the ground to the next point as illustrated by [6]. A being the first point, the handle of the chain is held there, and the first 50 links are measured off horizontally to B, and then plumbed to the ground (by dropping a stone or by a weighted cord) fixing point B. The remaining 50 links are measured off in the same way, and the point C fixed, and an arrow inserted there. The error which arises by measuring the sloping ground from A to C is what is termed *hypothenusal* error.

The chief errors that may arise in a chain survey besides those named,

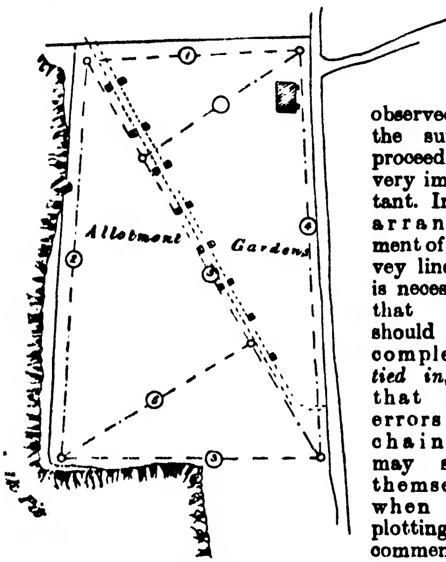


6. METHOD OF CHAINING SLOPING GROUND

and which have to be guarded against, are due:

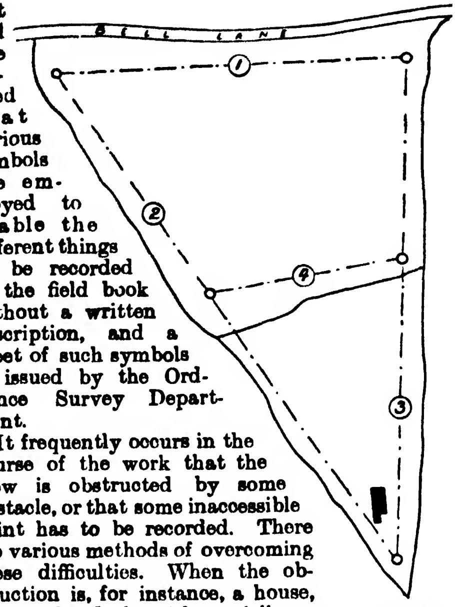
a. To the chain not being held tight.
b. To the handles not being held close against the arrows.
c. To the stretching of the chain by constant use.
d. To not keeping in proper alignment.

Considerable skill is required in determining the arrangement of lines for a survey best calculated to get the least number and yet to take in all the points satisfactorily. Also accurate notes are necessary, and sketches of all objects observed as the survey proceeds are very important. In the arrangement of survey lines it is necessary that they should be completely *tied in*, so that any errors in chaining may show themselves when the plotting is commenced, by the lines not properly joining. This can be illustrated by several sketches. The first [7] is that of a triangle which in itself is not complete, without the tie line, as shown. In the event of one of the lines being chained too short or too long, the only thing that would happen would be an alteration in the shape of the triangle, which, if the error were only slight, would not be noticeable. The tie line prevents this occurring. The second diagram [8] shows the arrangement of ties for a rectangular field, the position of the diagonal being chosen so as to act as a survey line to pick up the footpath. A more elaborate arrangement of lines is shown in 9. These tie lines are sometimes termed *chain angles*.



8. CHAIN SURVEY

For the purposes of plotting the survey, great care is required in keeping the field notes. The usual form of field book is shown in 10.

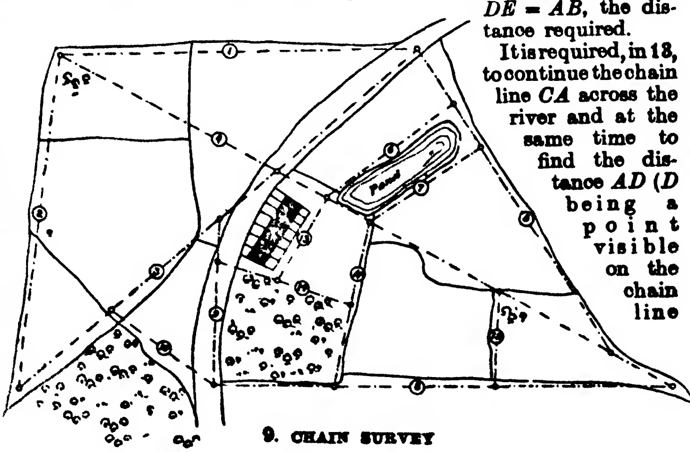


7. CHAIN SURVEY

It will be noticed that various symbols are employed to enable the different things to be recorded in the field book without a written description, and a sheet of such symbols is issued by the Ordnance Survey Department.

It frequently occurs in the course of the work that the view is obstructed by some obstacle, or that some inaccessible point has to be recorded. There are various methods of overcoming these difficulties. When the obstruction is, for instance, a house, it may be dealt with as follows. In 11 *Aa* is the chain line, which has to be continued towards *D*. Perpendiculars are set up at *A* and *a*, and equal distances, *AB* and *ab*, are measured to clear the obstacle. *Bb* is then ranged forward to *c* and *C*, and at these points similar perpendiculars are set up, the distances *cd* and *CD* measured, and made equal to *AB* and *ab*. *Dd* is therefore the direction of the chain line produced, and the length *bc* is the chainage of *ad* that could not be measured. The distance apart of the points *Aa* and *dD* should be sufficient to obtain a good range. Other methods are shown in 12 and 13. At *A* on the chain line *AA* in 12, a perpendicular *AC* is set up and is produced to *D*, making $AC = CD$. At *D* a perpendicular is set up and a straight line carried through *BC*, cutting it at *E*, making $DE = AB$, the distance required.

It is required, in 13, to continue the chain line *CA* across the river and at the same time to find the distance *AD* (*D* being a point visible on the chain line



9. CHAIN SURVEY

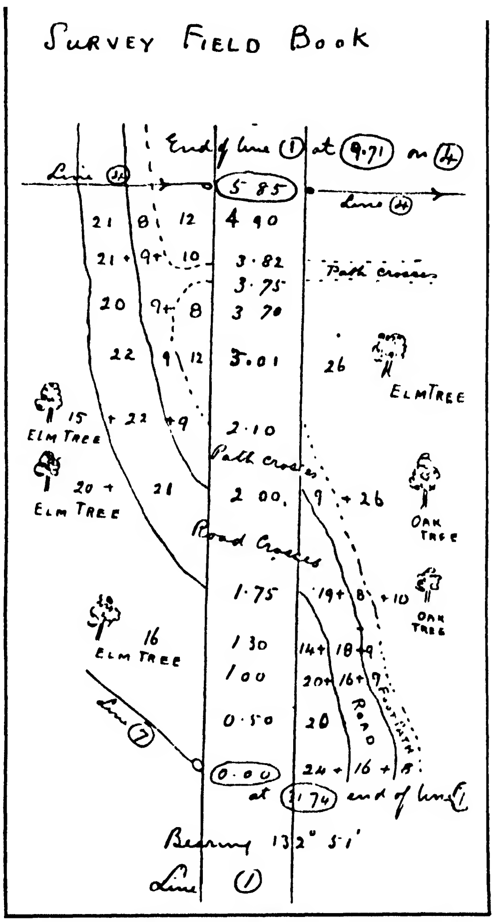
produced), and to clear the wood which obstructs the chainage. At A set up a perpendicular AB, and at B set up a perpendicular to BC, cutting the chain line produced at D.

$$\text{Then } CA : AB :: AB : AD$$

$$\therefore AD = \frac{AB^2}{AC.}$$

As it is possible to chain AB and AC, the distance AD can be calculated. If AB is made equal to $2AC$ the distance AD is $4AC$.

In the event of no instrument being available for setting up perpendiculars to a chain line, it can be accomplished by means of the chain alone. The proportions of the sides of a right-angled triangle may be as 3,4, and 5, or multiples of these numbers. It is required to set up a perpendicular to any point A [14] on a chain line. On each side of A measure off 30 links to B and C, and pin the chain handles down at these two points. If the centre brass tag of the chain be taken hold of and the chain pulled tight, a perpendicular can be ranged through the point D thus found. The triangle will, of course, have sides equal to 30, 40, and 50 links, and AD is perpendicular to the chain line BC.

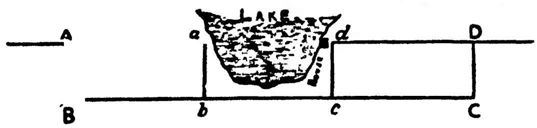


10. REDUCED FACSIMILE OF PAGE FROM A SURVEYOR'S NOTE-BOOK

It is necessary to be able to plot the position of the true north with regard to the lines of the survey. For extended surveys accurate methods must be adopted which will be explained hereafter, but for small surveys the following method suffices. At some convenient point on the survey we have a pole erected truly vertical, and with the pole as centre describe a circle round it. At any convenient time before noon mark the point at which the shadow of the pole thrown by the sun cuts the circle, and at the same number of hours after noon mark another point on the circle. The bisection of the angle formed by these two points and the pole give the north. In case the sun should be obscured at any time during the day, it is necessary to take several points at the right intervals before and after noon, so that there will be several chances of getting a result.

The most usual form of survey is by chaining the lines, and fixing their positions with regard to one another by angular measurements. In small surveys a combination of angular work and chainwork may be adopted. That is to say, the main lines may be checked by means of reading the angles between them, while the filling in of the minor details may be left to be done by the chain. In any case, the main lines are chained to get their lengths, and the tying of them together is done by reading with an instrument the angles they make with one another. In all work of this description the greatest care must be taken to place the instrument exactly over the point of intersection of the lines between which the angle is intended to be taken; also that in reading the angles the telescope of the instrument be first directed to the left-hand object, in order that the angle may be read from zero onwards, as the graduations of the instrument are from left to right. The instruments generally employed are the *Theodolite*, *Box Sextant* and *Prismatic Compass*, which are described in their proper place. The theodolite is the one chiefly used, the smaller instruments being employed in detail work, or for work involving less accuracy. In this part of the subject, dealing with small theodolite surveys, the lines are all chained in the ordinary way. For work of greater magnitude the lengths of the lines are calculated, as explained later. It is never advisable to trust to one reading of an angle, but it is usual to *repeat* the angle as follows. After the first angle has been taken and the plates clamped the instrument is again turned on the first point, but with this difference, that instead of starting with zero on the first point, the telescope (with the angle just observed on the plate) is sighted on to the point, so that the

second reading should be the sum of the two angles. This should be repeated a third time, and the sum of the differences of the three angles thus obtained, divided by three, will give the mean angle. An illustration of this is as follows:

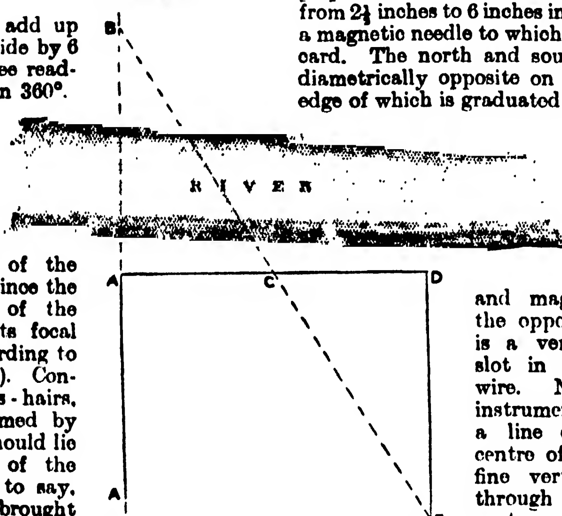


11. OBSTRUCTION TO CHAIN LINE

	ANGLE.	DIFFERENCE.
1st reading	175° 30′	175° 30′
2nd „	351° 0′	175° 30′
3rd „	166° 30′	175° 30′
	3)	526° 30′
	Mean =	175° 30′

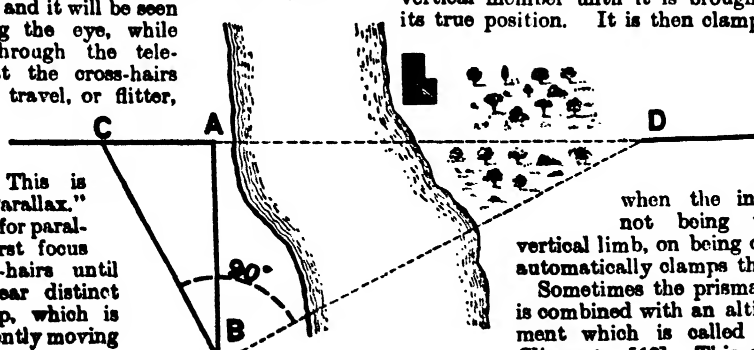
It is incorrect to add up the readings and divide by 6 unless the whole three readings come to less than 360°.

Parallax. The eyepiece of the telescope of any instrument, such as the theodolite, serves to give a distinct and magnified view of the image. Therefore, since the magnifying power of the eye-piece is large, its focal range is small (according to its magnifying power). Consequently the cross-hairs, and the image formed by the objective lens, should lie in the focal plane of the instrument, that is to say, the image must be brought on to the cross-hairs. The plane of the cross-hairs is fixed, while that of the image moves backwards and forwards, according to the movement of the objective lens (as when focussing). Therefore, the coincidence of the image and cross-hairs in the focal plane is imperfect, and it will be seen by moving the eye, while looking through the telescope, that the cross-hairs appear to travel, or flitter, over the surface of the image. This is called "Parallax." To adjust for parallax we first focus the cross-hairs until they appear distinct and sharp, which is done by gently moving the eye-piece in or out. The objective lens is then moved until the image comes into perfect focus. These operations are repeated until there is no perceptible movement of the cross-hairs. When once the adjustment for parallax has been made for the day, no further attention is required so long as the same person uses the instrument, but another individual with a different focal range would have to carry out adjustments to suit his vision. It should be remembered that adjustment for parallax should be made previous to that for Collimation, which is explained elsewhere.



12. CHAIN LINE OBSTRUCTED BY RIVER: METHOD OF CROSSING

Prismatic Compass. This instrument [15] consists of a circular metal box, varying from 2½ inches to 6 inches in diameter, containing a magnetic needle to which is attached a circular card. The north and south of the needle are diametrically opposite on the card, the rim or edge of which is graduated into degrees and half degrees. The north of the needle is fixed at 180°, the south at 360°, or zero. The box is fitted on one side with a combined sighting slot (*s*) and magnifying prism. On the opposite side of the box is a vertical limb, with a slot in it, carrying a fine wire. Now, assuming the instrument is resting at zero, a line drawn through the centre of the slot (*s*) to the fine vertical wire will pass through the card at 360°, its centre, and 180°. In taking a reading we sight through the slot, and bring the fine wire on to the distant object, the "bearing" of which has to be determined. The card will sway a little, but this can be checked by a finger clamp at the base of the vertical member until it is brought to rest in its true position. It is then clamped, and the reading taken. The prism and vertical limb can be shut down when the instrument is not being used. The vertical limb, on being closed down, automatically clamps the needle.

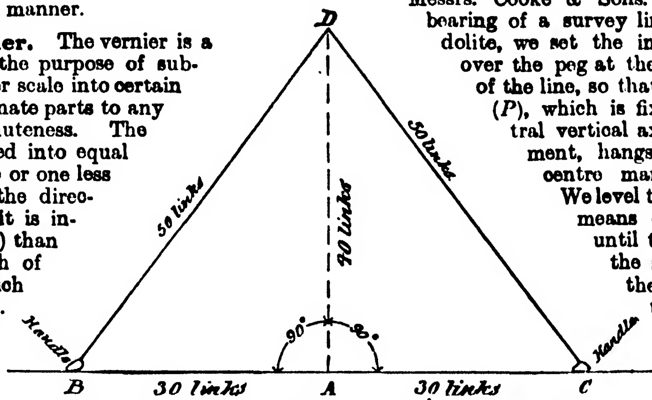


13. CHAIN LINE OBSTRUCTED BY RIVER: METHOD OF CROSSING

Sometimes the prismatic compass is combined with an altitude instrument which is called a *Prismatic Clinometer* [16]. This consists of a prismatic compass (as previously explained) and a circular box con-

taining a loaded and graduated card. The instrument stands on a base. By looking through the slot, as depicted by the illustration, and tilting the instrument on its base till the alignment of the slot, hair, and the object is correct, the degrees of inclination can be read in the ordinary manner.

The Vernier. The vernier is a scale made for the purpose of subdividing another scale into certain equal proportionate parts to any degree of minuteness. The vernier is divided into equal parts, one more or one less (according to the direction in which it is intended to read) than an equal length of the scale to which it is to work. Fig. 17 depicts a scale (A), divided into degrees, which are subdivided into half degrees. The length of the vernier for this scale is taken to equal 29 of the subdivisions or half degrees. This length is equally divided into 30 parts. Each part will, therefore, be $\frac{1}{30}$th (or one minute) less than a half degree subdivision. From this it will be seen that if the vernier arrow is moved forward one minute on the great scale it will be recorded on the vernier scale. Figure 17 shows a vernier indicating an equal number of degrees on a great scale (A), while 18 shows a vernier indicating a reading of 23° 12′ on the great scale (B).



14. SETTING UP A PERPENDICULAR WITH THE CHAIN

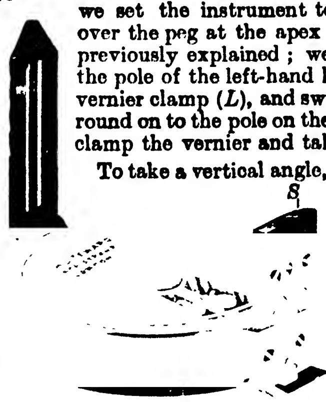
Box Sextant. The box sextant is a hand instrument [19] for measuring angles up to 130°. It consists of a circular metal box (about 3½ inches in diameter) containing two glasses, one movable and the other fixed. The fixed glass is silvered on the upper half, the lower being clear, while the movable or reflecting glass is silvered all over. The thumbscrew D operates the movable mirror. The angle between the object observed by the eye and the reflected object is recorded by the vernier on the index arm which works along the grand circle. The method of obtaining the angle between two objects is as follows: Sight (by means of the telescope T) through the clear portion of glass on to the left-hand object; operate the screw D until the right-hand object appears (by reflection) on the upper or silvered portion of the fixed glass. When the reflected and the observed object coincide, the reading may be taken, and the value of the angle obtained. In order to facilitate the reading of the vernier a magnifying glass is provided.

In cases where the objects are not far apart the telescope is dispensed with and drawn out, the opening in which it rested being covered by a slide with a small hole in its centre. Looking through this hole serves the same purpose as looking through the telescope.

The Transit Theodolite. This instrument [20] is explained by one made by Messrs. Cooke & Sons. To take the bearing of a survey line with a theodolite, we set the instrument firmly over the peg at the commencement of the line, so that the plumb-bob (P), which is fixed to the central vertical axis of the instrument, hangs truly over the centre mark on the peg. We level the instrument by means of the screws (s) until the air bubble in the spirit level is in the centre. Having the instrument level, we clamp the vernier (A) to zero on the graduated circle (B) by means of the clamping screw (L). The final adjustment of the vernier is made by the tangent screw (T). Now release the clamp (K), which will enable the whole instrument to be revolved (without altering the zero), and set it up by the compass needle attached to the instrument to magnetic north. The final adjustment is made by the tangent screw t_1. The instrument being now at zero and pointing to the magnetic north, release the vernier and swing the telescope round from left to right until it rests on the pole on the end of the line. Carefully adjust the telescope by the tangent screw (T) until the cross-hairs in the instrument cut the centre line of the pole. The bearing can now be read by the vernier, and will be a *forward bearing.* This operation is repeated with the instrument set up at the other end of the line and the telescope turned on to the first pole. The reading obtained will be a *backward bearing;* the difference between the two should be 180°, which is a check on the work.

To take a horizontal angle with the theodolite we set the instrument to zero and place it over the peg at the apex of the two lines as previously explained; we then turn it on to the pole of the left-hand line. Releasing the vernier clamp (L), and swinging the telescope round on to the pole on the right-hand line, we clamp the vernier and take the reading.

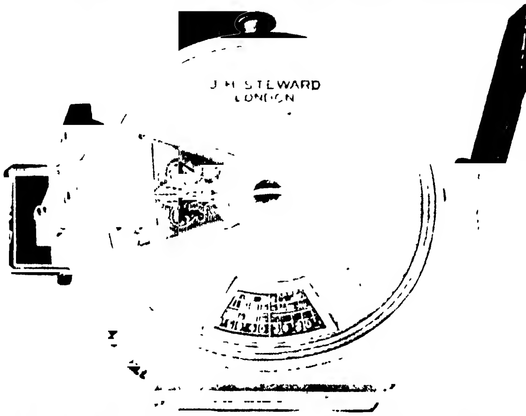
To take a vertical angle, set the vernier (V) (on the vertical graduated circle D) to zero, depress the telescope for a negative angle, and raise it for a positive angle, obtaining the value by means of the vernier.



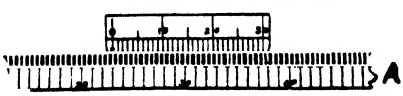
15. PRISMATIC COMPASS

The vertical motion of the telescope is governed by the clamping screw (H) and the tangent screw i_4.

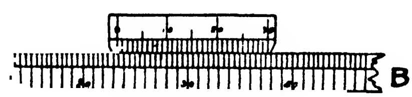
Theodolite Adjustments. In adjusting the levels on the horizontal plate perpendicular to the vertical axis of the instrument we set up the instrument firmly on good solid ground, release the lower clamping screw and turn the head until the longer of the two levels lies in a direction parallel to an imaginary line joining the centres of two of the foot-screws. The shorter tube then lies towards the third. Now level the instrument by means of the foot-screws, so that both bubbles lie in the middle of their runs. Then turn the head of the instrument one half round in azimuth, that is to say, through an angle of 180 degrees. If the bubbles remains true they are in perfect adjustment, but if not, then by means of the capstan-headed lock-nuts (c, c), by which the larger one is attached to the horizontal plate, correct it for half the error only, and for the other half by means of the foot-screws.



16. PRISMATIC COMPASS AND ALTITUDE INSTRUMENT



17. THE VERNIER



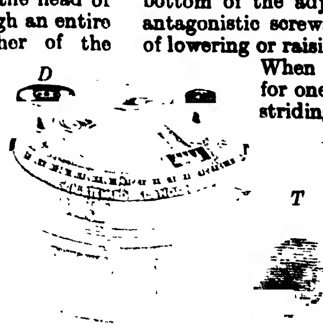
18. THE VERNIER

Now complete the revolution of the head, bringing it to its first position, and again notice this bubble. If it is not quite exact, the same operation must be repeated, that is to say, half the error must be again eliminated by means of the capstan-headed nuts, and the other half by means of the foot-screws. By repeated trials this level can thus be eventually exactly corrected, after which the smaller bubble may be compared with and adjusted by it, and when the head of the instrument can be twisted through an entire revolution without disturbing either of the bubbles from their positions in the middle of their runs, the levels are in perfect adjustment.

The same adjustment can be made by reference to the level which is mounted on the vernier arms of the vertical circle, sometimes called the azimuth level. This bubble is of more delicate construction than those on the horizontal plate, so that by its use greater accuracy may be attained. It must first be carefully corrected, so that the head of the instrument may be turned in azimuth through an entire revolution without disturbing the position of the bubble, after which the levels situated on the horizontal plate can be compared with and adjusted by it. The operation is, however, of somewhat longer duration, and as the method given above will be found sufficiently accurate for all practical purposes, no further description of it is given here.

Transit Axis Adjustment. The adjustment of the transit axis so as to be truly horizontal is effected by means of the antagonistic screws (a, a) situated just below one of the Y bearings, and can be carried out with the aid of a striding level. It is an adjustment that is not likely to require much attention, for having once been carefully corrected by the maker of the instrument nothing but very rough usage can possibly displace it again.

Having levelled the instrument carefully by means of the bubbles on the horizontal plate, and noticed that this adjustment is perfect, turn back the caps which cover the ends of the transit axis in its bearings. Now erect the striding level on the top of the axis just over the bearings, and observe it carefully. (Reverse it, in order to examine its own adjustment, and if any error be discovered, this must be corrected before proceeding further.) If the bubble does not remain in the middle of its run, it must be made to do so by slightly opening or closing the slit in the bottom of the adjustable Y, by means of the antagonistic screws (a, a), which has the effect of lowering or raising the end of the transit axis. When the adjustment is completed for one position, the bubble in the striding level ought to remain steady while the head is twisted in azimuth through an entire revolution.



19. BOX SEXTANT

This same adjustment may be accomplished without the aid of a striding level in the following manner: Set up the instrument at about forty or fifty feet distance from

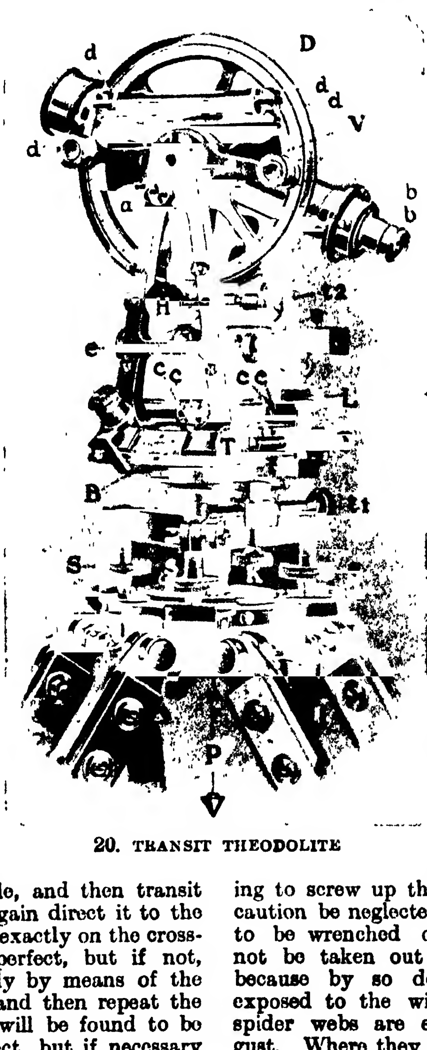
a high wall or other object of considerable elevation, level it carefully, and direct the telescope to some small point situated as high up as possible, and bring the cross lines to bear exactly upon it. All parallax (as previously explained) must now be carefully eliminated. Tilt the telescope and make a small mark on the wall near to the foot, at the point of intersection of the cross lines. Now turn the telescope 180 degrees in azimuth, transit it, and again direct it to the upper mark, after which tilt it as before and see if the point of intersection of the cross lines exactly corresponds with the lower mark. If it does so the transit axis is truly horizontal, but if not, half the error must be corrected by means of the antagonistic screws (*a*, *a*) as previously described, and the operation repeated in order to ensure accuracy.

Horizontal Collimation. The adjustment of the central line of vision of the telescope perpendicular to the transit axis, in other words, *horizontal collimation*, is effected by means of the pair of antagonistic screws (*b*, *b*) situated near the eye end of the telescope.

Having carefully levelled the instrument, direct the telescope to some small object, such as a pin-hole in a piece of white paper, fixed at as great a distance as can be distinctly seen, and by means of the lower tangent screw bring the centre of the webs to fall exactly upon it, all clamps being firm. Now having turned back the covers of the bearings and loosened one of the clipping screws (*e*, *e*) at the lower extremity of the vernier arm, gently lift the upper part of the instrument and reverse the transit axis in its bearings. Release the clamp to the vertical circle, and then transit the telescope, after which again direct it to the previous object. If it falls exactly on the cross-hairs the adjustment is perfect, but if not, correct half the error only by means of the antagonistic screws (*b*, *b*) and then repeat the operation. This time it will be found to be almost, if not quite, correct, but if necessary again divide the error by means of the screws, and so on until the adjustment is perfect. No adjustment is provided or required for vertical collimation with this instrument.

To adjust the level attached to the vernier arms of the vertical circle, so that when the central line of vision of the telescope is horizontal, and the zero lines of the vertical verniers coincide with the zero diameter of the vertical circle, the bubble may be in the middle of its run, we manipulate the capstan-headed lock-nuts (*d*, *d*) that attach the level bubble to the vernier arms.

Having levelled the instrument carefully by means of the bubbles on the horizontal plate, bring the bubble in the azimuth level to the middle of its run by means of the antagonistic screws (*e*, *c*) at the end of the clipping arm. Now set the zero diameter of the vertical circle to coincide exactly with the zero lines on the vertical verniers, and clamp it there. Observe an ordinary levelling staff held at as great a distance as it can be distinctly seen, and take the reading by the horizontal web. Now release the clamp and transit the telescope, and again adjust the zero diameter of the vertical circle to the zero lines on the verniers. Revolve the head in azimuth one half turn, bringing the telescope to its former position, and once more take the reading of the staff. If it is not the same as previously observed, correct half the error by the antagonistic screws at the end of the clipping arm and then repeat the operation until all error is by this means eliminated. When the adjustment is complete correct the azimuth level by means of the capstan-headed lock-nuts, so that the bubble remains in the middle of its run.



20. TRANSIT THEODOLITE

The adjustments referred to above must be carried out with the greatest care in order to avoid damaging the instrument. For example, in operating the capstan-headed nuts, care must be taken to unscrew one before attempting to screw up the other. Should this precaution be neglected, the screw heads are apt to be wrenched off. The eye-piece should not be taken out of its tube in the field, because by so doing the cross hairs are exposed to the wind, and if constructed of spider webs are easily broken by a sudden gust. Where they are constructed of platinum wire, or are marked on glass, these precautions are unnecessary.

After the instrument has been used in the field, and before being placed in its box, it should be carefully wiped over with a duster slightly oiled.

To be continued

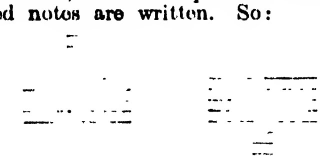
Group 22
MUSIC
2

THE WHOLE LANGUAGE OF MUSIC

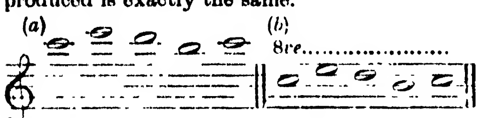
Illustrated Interpretations of the Terms and Phrases employed, with Explanations of Scales, Modes, and Key-signatures.

By J. CUTHBERT HADDEN

WE return now for a little to the Stave. If we were to fill up the whole of our Great Stave of 11 lines and 10 spaces, we should still leave unexpressed a very large number of musical sounds. Count, for instance, the keys of a piano: there are 85 notes in the compass of seven octaves. Even human voices take us beyond the limits of the Great Stave. How, then, are the extreme sounds, high or low, shown in musical notation? They are expressed on what might be called a borrowed stave, borrowed just as it is required. Little lines are added temporarily, and on these, or in the spaces so created, the required notes are written. So:



These additions are called technically *Leger lines*, "leger" being simply the French word for "light." There is no limit to the addition of leger lines, though for convenience, and not too greatly to distract the eye, a series of notes which would run much above or much below the stave is often written an octave higher or lower than the pitch required, and the direction added to render the passage an octave lower or higher as the case may be. Thus (*b*) is less troublesome to write than (*a*), and the effect produced is exactly the same.



The term *octave* ought perhaps to be explained here. As only seven letters are used in naming the lines and spaces of the stave, it is obvious that when one set of seven is exhausted we must begin with another. The name-letter with which we begin the second series will of course be the eighth of the first series, and it is from this circumstance that the term octave (or eighth) is derived. The arrangement that any sound and its octave shall bear the same name is, as Dr. W. H. Cummings observes, in accordance with nature, for we find that, although there is a difference in pitch or height, yet the two sounds (test it on the piano) so accord together that they seem to be almost like one sound.

In the writing of music much space is saved by the use of abbreviations, signs for repeats, for "embellishments," for manner of performance, and the like. We will take the *Repeats* first. These are indicated in various ways. If the composer wants the performer to repeat from the beginning he employs the term *Da Capo* or its abbreviation *D.C.* In that case the repetition continues until the term *Fine* occurs, or a *Pause* mark (𝄐) is seen over a double bar. Another way of indicating a repeat is founded on various uses of the Italian word *Dal Segno* (from the sign). The "sign" may be in the form of an 𝄋 or the initial letters *D.S.*; in any case the repeat will be made from the sign, whatever it is. A third method employs dots before or after a double bar. Thus:

Here the first illustration indicates a repetition of the preceding movement; the second a repetition of the following movement. If a short passage—say two or three bars—is to be repeated, the term *Bis* (twice) is written over the stave. Very often an alteration has to be made of the close of a repeated portion, in which case the indication is—

Many other space-saving devices are met with, most of which are best explained to the eye, as here:

The latter example is termed an *Arpeggio*, and means literally after the manner of the harp,

where the notes of a chord are played quickly one after another.

As regards manner of performance, the *Slur* and the two kinds of *Staccato* marks are the most frequently used of what may be called non-notational abbreviations. The slur is a curved line drawn over or under a group of notes to indicate that they are to be performed in a smooth, connected manner, or, in the case of a setting of words, that the notes so marked are to be sung to one word or syllable:

The term *Legato* also indicates a smooth style of performance, but is generally used as a direction for long passages. The slur, unfortunately, is made to do double duty, for it is employed also as a *tie* or *bind* between two notes on the same degree of the stave when the second note is to be joined to the first. When notes are to be sung or played in a crisp, short, disconnected manner, dots and dashes called *Staccato* marks are introduced—a dot when the note is to be robbed of a very slight portion of its legitimate time; a dash when the effect is to be still shorter.

Among abbreviations which are not strictly notational must also be noticed the marks < and >, which signify, the first a *Crescendo* (generally written *Cres.*), increasing in loudness: the second a *Decrescendo* (*Decres.*), decreasing in loudness. The terms themselves and the signs are used indiscriminately. Again, there is the mark of emphasis, indicated either by > or ∧ placed over the note or chord to be affected. A very strong emphasis is expressed by *sf* or *sfz*, standing for *sforzato* (forced); while a reinforcement of tone is indicated by *rf* or *rinf* (*rinforzando*). The most frequently used of all abbreviated directions affecting the intensity or strength of sound are, however, the following:

f, *forte*, loud.
ff, very loud.
fff, as loud as possible.
mf, *mezzo-forte*, moderately loud.
mp, *mezzo-piano*, moderately soft.
p, *piano*, soft.
pp, very soft.
ppp, as soft as possible.
fp, loud, then soft.

The subject of embellishments would require a volume to itself; and indeed the student who desires to master all its details must be left to consult Mr. Dannreuther's "Primer of Ornamentation" where the theme is treated exhaustively. Here we can notice only the most common forms of ornamentation. First comes the *Shake*, an ornament produced by the rapid alternation of two consecutive notes (*a*). The Italian word for shake is "trillo," and the sign for this embellishment is simply a contraction of "trillo"—*tr*. When the shake is to be prolonged through several bars, as at the close of Mendelssohn's Wedding March, a waved line after the *tr* indicates how far the ornament is to continue.

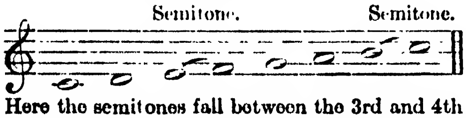
The shake frequently, though not always, ends with a *Turn*, another ornament representing a group of five notes. It exists in two forms, the direct and the indirect. The sign for the direct turn is ∼; for the indirect turn ≀. The direct turn begins with the note above the one written (*b*); the indirect with the note below (*c*). A sharp or flat accompanying the sign of the turn shows that the note above or below the written note is to be sharpened or flattened (*d*).

The shake and the turn are thus expressed by signs: other embellishments are expressed by small notes. The one most frequently met with in older music is the *Appoggiatura*. The term comes from the Italian "appoggiare," to lean upon; and this is an ornament which "leans upon" a principal or accented note. It takes half the length of the note which follows it, except when the principal note is dotted, when it takes two-thirds (*e*). In modern music it is more usual to write the appoggiatura in the text as a full-sized note with its proper value. The older composers never did this, and it is necessary to understand exactly what they meant when they wrote the small note.

The *acciaccatura* is the only other small note ornament that need be noticed. It is generally marked with an oblique line through the head of the note, and is always to be sounded as a very short note, proceeding immediately to the principal note (*f*).

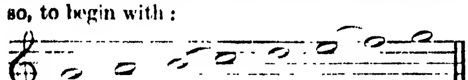
We now take up the subject of scales and modes. "Scale" is one of the most familiar terms in music. The word comes from the Latin *scala*, a ladder.

And a ladder the scale, in fact, is: a series of notes having a gradual and regular ascent or descent, by tones and semitones, from any given note to its octave. In modern music two scales only are recognised—the diatonic and the chromatic. The term diatonic, derived from Greek words meaning "through a tone," sufficiently indicates the nature of the scale to which it is applied, this scale consisting chiefly of tones—that is to say, whole tones. Set down in notation, taking the major diatonic scale of C as a model, it appears thus:

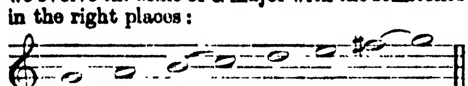


Here the semitones fall between the 3rd and 4th and 7th and 8th degrees, all the other intervals being distant a whole tone from each other.

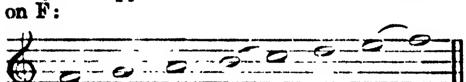
This scale of C is often called the "natural" scale, because it is written without sharps or flats, and because it can be played entirely on the white keys of a piano. It is, at any rate, the type or model upon which all other major scales are formed. Every major scale, beginning on whatsoever note, must, like this "natural" scale, have its semitones between the 3rd and 4th and 7th and 8th degrees, with full tones between the remaining degrees. Let us see, then, how other scales are constructed on this pattern. Say we want to rear a scale on the note G. We write it so, to begin with:



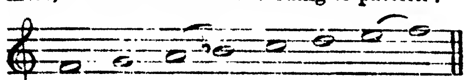
But we see at once that something is wrong, for the second semitone is between the 6th and 7th degrees when it ought to be between the 7th and 8th. Obviously, to correct this we must raise the pitch of F by placing a sharp before it, so as to make it a whole tone higher than E and consequently a semitone lower than G. Thus we evolve the scale of G major with the semitones in the right places:



Again, suppose we desire to commence a scale on F:



Here it is the first semitone that is misplaced: instead of being between the 3rd and 4th, it is between the 4th and 5th degrees. To correct that error it is necessary to lower the fourth note B by placing a flat before it. Then, once more, we have our scale according to pattern:

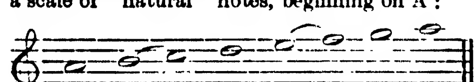


The same procedure applies in the case of major scales formed on other notes. A scale on D will require two sharps to set the semitones in order; a scale on E flat, three flats; a scale on E, four sharps, and so on.

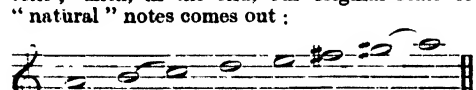
It would be very inconvenient to have to write these sharps or flats every time the notes requiring them appeared; hence they are written, once for all, at the beginning, just after the Clef sign. Arranged in this way they are termed the *Key-signature*. They are always placed in the order in which their use has been called for: in the case of the sharps, F, C, G, D, A, E, and B sharps; in the case of the flats, B, E, A, D, G, C, and F flats. The student must learn to tell at once what key any given signature represents. With that object in view we set down here a complete table of all possible signatures;

Let it be added that the keys of C♯ and C♭ are very seldom used, being (on keyboard instruments at least) identical with D♭ and B, which are much more easily written.

Having thus disposed of the major diatonic scale, we must now consider its relative, the minor scale. Here again it is a question of the order of the tones and the semitones. The major scale is so called because the interval of the third from its first note is major, that is, two whole tones and a half tone. The minor scale, on the other hand—hence its name—has only a tone and a semitone between its first and third notes. We will make an experiment and write a scale of "natural" notes, beginning on A:



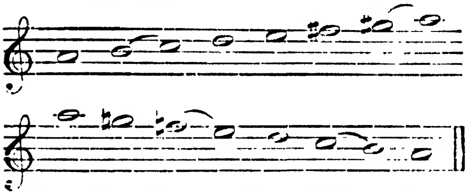
Here the distance from A to C is a tone and a half, a minor third; and that is what determines the scale. It is a minor scale. It can be sung or played with satisfaction to the ear as far as the seventh note. Then the ear—the modern ear—long accustomed to the ascent by a semitone from the seventh to the keynote in major keys, seems to demand a similar progression in the minor, so that we are obliged to alter the G to G♯. Unfortunately, this creates an awkward gap of an augmented second—a tone and a half—between F and G♯; therefore, to make a smoother melodic progression, the sixth note of the ascending minor scale is often raised a semitone; until, in the end, our original scale of "natural" notes comes out:



This is the commonest order of the ascending minor scale; but the other form, with the sharpened seventh only, is also used, while the

"natural" notes series was a great favourite with the old Church music composers, who did not feel anything of the modern desire for a semitonic leading note to the key.

In the descending minor scale the form of the ascent is generally changed so that only the natural notes appear.



The explanation of this apparent vagary is easy enough. In descending, the need of a "leading note" is not felt; and with the seventh note standing at its original pitch, a raised sixth note is also unnecessary. Nevertheless such phrases as these:

are quite common in classical music. The student will find, as his theoretical and practical knowledge advances, that the minor scale is subject to many whims on the part of composers.

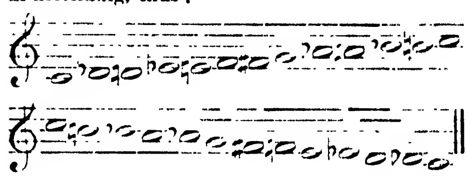
Return now to the subject of key-signatures. We have seen how these signatures are used to represent certain major keys. In addition to this, they denote also certain minor keys, known technically as the "relatives" of respective major keys. Two keys or scales are said to be relative when they contain the same, or nearly the same, notes. Thus, a scale of "natural" notes beginning and ending on A is "relative" to the scale of C major. In other words, when notes which are natural, sharp, or flat in one key are natural, sharp, or flat in another key, they are called "relative." Here, however, the student must remember that such sharps or flats as may be used for the 6th and 7th degrees of the minor scale are not included in the key-signature, but are prefixed to the notes as they occur.

Strictly speaking, it is incorrect to say that "the keys C major and A minor are relative keys because in each all the notes are natural," for in A minor, as generally written, all the notes are *not* natural. So far, however, as the key-signature is concerned, the theory of "relative" keys holds good. Every key-signature represents not only a certain major key, but also its relative minor—the key which stands a minor third below the major keynote. Thus, a signature of one sharp means either G major or E minor; four flats A♭ major or F minor. Here is a table which will be serviceable to the student in this connection:

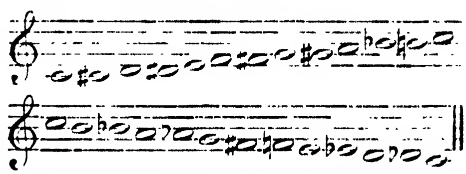
Major and Minor Scales having the same Signature.

C Major	A Minor
G ,, ...	E ,,
D ,, ...	B ,,
A ,, ...	F♯ ,,
E ,, ...	C♯ ,,
B Major	G♯ Minor
F♯ ,, ...	D♯ ,,
C♯ ,, ...	A♯ ,,
F ,, ...	D ,,
B♭ ,, ...	G ,,
E♭ ,, ...	C ,,
A♭ ,, ...	F ,,
D♭ ,, ...	B♭ ,,
G♭ ,, ...	E♭ ,,
C♭ ,, ...	A♭ ,,

One more scale has to be considered, namely, the *chromatic*. A diatonic scale is made up of tones and semitones; a chromatic scale moves entirely by semitones. Thus, if you sit down to the piano and sound *every key*, black and white, from one C to the next C, you produce a chromatic scale. In theory there is no difficulty about the chromatic scale: in the matter of writing it there is considerable difficulty and no little confusion. Some theorists write it so as to make it notationally the same in descending as in ascending, thus:



With other theorists it takes this form—



Still others would write the ascending B♭ and the descending F♯ here as A♯ and G♭. For facility in performing, perhaps the form of ascent by sharps and descent by flats is to be preferred; but the other forms are more scientific and better suited for harmonic purposes. This, however, is a point which can be appreciated only by advanced students.

In order to facilitate reference to the respective degrees of the scale apart from the pitch, the following technical names are in use:

1st degree	Tonic or Keynote.
2nd ,, ...	Supertonic.
3rd ,, ...	Mediant.
4th ,, ...	Subdominant.
5th ,, ...	Dominant.
6th ,, ...	Submediant or Superdominant.
7th ,, ...	Leading note or Subtonic.

These terms find their most frequent use in the study of harmony, for which purpose they must be carefully committed to memory.

So far we have familiarised ourselves with three intervals only—the tone, the semitone, and the octave. We are now prepared to look at the subject of intervals in more detail. It is hardly necessary to give a definition of the term interval,

which is readily described as the distance from one note to another. Intervals are generally reckoned upwards, and are named by the number of scale sounds they contain, the extremes being included in the reckoning. Thus, from C to F is a fourth, because four notes are involved; from D to A is a fifth, because five notes are involved; and so on. The numeral of any interval is thus quite easily ascertained. But we must go farther than this. One third (C to E, for example) may cover four semitones, while another third (say, D to F) covers only three. It is this distinction which leads to the use of the terms major and minor (greater and lesser), perfect and imperfect, as applied to intervals. The seconds, thirds, sixths and sevenths are known as major and minor; the fourths and fifths as perfect and imperfect. In the following table the number of semitones of which each interval is made up is given. As Stainer says, it is quite unnecessary to commit to memory the number of semitones contained in all the possible intervals.

TABLE OF DIATONIC INTERVALS.

Minor second	1 semitone.
Major second	2 semitones.
Minor third	3 "
Major third	4
Perfect fourth	5
Pluperfect (or augmented) fourth	6
Imperfect (or diminished) fifth ..	6
Perfect fifth	7
Minor sixth	8
Major sixth	9
Minor seventh	10
Major seventh	11
Perfect octave	12
Minor ninth	13
Major ninth	14

No interval is reckoned beyond a ninth, which is indeed itself, regarded as a compound second. With this exception, intervals which exceed the octave are generally regarded as replicates of those that do not. In the case of the pluperfect fourth and the imperfect fifth, one or two points have to be observed. Both intervals contain six semitones, but in the one case four and in the other case five scale letters are involved:

The pluperfect fourth covers three whole tones, for which reason it is sometimes called the tritone. Only one pluperfect fourth and one imperfect fifth are found in the diatonic scale, the first always on the subdominant and the second always on the leading-note. For this reason they have their own peculiar names.

All these intervals are known as diatonic intervals because they occur in the unaltered diatonic scale. But just as we have our chromatic scale, so we have our chromatic intervals. Suppose we take from the chromatic scale these two pairs of notes:

It is clear that neither pair belongs to any diatonic scale. The first is greater, by one semitone, than a major sixth; the second is less, again by one semitone, than a minor sixth. Therefore both must be chromatic intervals: they cannot be traced to any key. In short, a chromatic interval is an interval not found in the diatonic scale. Such intervals are of two kinds—augmented and diminished. These terms are self-explanatory, the intervals to which they are applied being augmentations and diminutions of diatonic intervals. When the interval is greater by a chromatic semitone than the major or perfect interval it is called augmented; when it is less by a chromatic semitone than the minor interval it is called diminished.

Students are at first apt to confound augmented seconds with minor thirds, augmented fifths with minor sixths, etc., these having the same number of semitones between them respectively. The error is easily avoided by counting the stave letters which are involved. Thus, A to C must always be a third, because three letters (A, B, C) are involved. The augmented second, A to B♯, contains the same number of semitones (three), but only two letters are involved. We may sharpen or flatten one or both notes of an interval, but the process can never alter the number of degrees in the interval; only the *quality* of the interval is affected. It must be admitted that a good deal of practice is required in order to attain the ready naming of intervals, but practice will assuredly bring perfection.

Reading Music. It has been said that a musician ought to be able to "read" notation as one reads a book. The process is hardly analogous; for the musician has usually to convert his reading into practice—a singer by his voice, a player by his fingers—whereas the book-reader has only to allow the impression of the words to act automatically on his brain. But undoubtedly facility in the reading of his notation is a great point with the musician. It is only to be acquired by much practice; in particular by constant and systematic reading "at sight." In taking up a piece, always look carefully at the key and time signatures. Be sure of your "scale"—of what notes are sharp or flat. Remember the transitions to other keys that are most likely to occur. If you are a singer, it is best to read by the movable *Doh*; that is, find out on what line or space the *Doh* (or keynote) is, and then calculate the other intervals accordingly. Vocal reading without reference to the key relationship of the tones is at best a tedious and uncertain method, to be acquired indeed only by exceptional persons. To the player a practical knowledge of harmony is of inestimable value in the "reading" of music.

To be continued

Group 3
BIOLOGY
2

THE MARVELS OF THE CELL OF LIFE

The Vegetable Kingdom. The Essential Unities and Differences of all Forms of Living Matter. Nature's Economy of Energy

By Dr. GERALD LEIGHTON

EVEN the most superficial observer cannot fail to be struck with the immense variety of creatures amongst the Invertebrates, and also with the fact that some groups have very little in common with others. There is no common plan of structure or type as was seen in the five Vertebrate groups. On the other hand, each group of Invertebrates is on the same footing as the whole Vertebrate group, for each has its own type of growth. No two animals could be more unlike each other than a star-fish and a tape-worm, or an oyster and a flea. To emphasise the *existence* of these wide divergences is our present purpose, preparatory to enquiring into their mode of origin: more detailed information concerning their structure and life-history will be found in the Natural History section of this work.

Animals and Plants. Having taken this brief survey of the animal world, we may turn our attention for a moment to the other great division of living matter, the vegetable kingdom, and see wherein lies the distinction between animals and plants.

The science of Life, Biology, is concerned with *all* living things, whether they be plant or animal, and deals with every possible point of view. It is only concerned with inanimate matter in so far as minerals are concerned in building up animal or plant bodies, or in the study of mineral bodies or fossils of plants and animals. The non-living objects in the Mineral Kingdom all show the following characters: Their chemical composition is relatively simple, being either a single element like gold, or simple compounds of two or three elements, as common salt. When unmixed, all mineral bodies are composed of similar particles, that is, they are *homogeneous*. In form and shape they are either indefinite (*amorphous*), or crystalline; in the latter case the shapes are made of plane surfaces and straight lines. If they show any increase in size, as, for example, some crystals, the increase is due to simple accretion of matter, and not to any true process of growth in the ordinary sense. Finally, all minerals agree in this, that all their phenomena are physical or chemical purely, and there is no tendency to periodic changes of any sort whatever, such as characterise living tissues. It follows that the study of non living matter is embraced in the sciences of Physics, Chemistry, and Mineralogy.

Five Characters of Living Matter. If we compare these non-living objects with animate matter, we find that there are a number of points in which all living things, both plant and animal, differ from them and have in common with each other. To begin with, the chemistry of living matter is that of comparatively few chemical elements, of which *carbon*, *hydrogen*, *nitrogen* and *oxygen* are the most important. These four elements are combined to form what are termed complex organic compounds, all of which contain a considerable proportion of water, and are easily decomposed. Next, all living tissues are largely composed of the substance called *protoplasm*, a substance which is in itself homogeneous, but which has the capacity by its growth of giving rise to *heterogeneous* tissues adapted for various functions; in other words, it can grow into different *organs*. Whether it thus grows or not, all the phenomena of Life are bound up in this protoplasm. Thirdly, as has been already inferred, living things are able to *grow* in the true sense of that term. That is to say, they can take into themselves matter from without, and so act upon it that it becomes part and parcel of their own living selves. This process is termed *assimilation*. Next, in contrast to the fixed stability of minerals, living tissues are in a constant state of change; indeed, it is this never-ceasing change which results in the cycle of alterations constituting Life.

Finally, and most characteristically, all living cells or bodies have the marvellous power of detaching or setting aside portions of themselves which, under favourable conditions of nutrition and environment, are capable of developing into cells or bodies similar to those from which they were separated. In a word, living cells possess the power of *Reproduction*.

The Physical Basis of Life. Every object which exhibits these five characters is either a plant or an animal; it is alive, and it has its life in virtue of being composed largely of protoplasm. It is for this reason that protoplasm is termed the physical basis of life, and this makes it a matter of importance to study the characters of protoplasm a little more closely.

The relation of protoplasm to the structure of the individual cell will be found fully dealt with in the section of this work devoted to PHYSIOLOGY. We wish at this point to draw attention merely to the fact that three great living characters are bound up with this substance. They may be termed the essential vital phenomena.

The first of these phenomena is that of *Metabolism*. Protoplasm is a very unstable substance, because of its chemical complexity and its large proportion of water. It is therefore constantly being destroyed and as constantly

renewed. The processes concerned are those of metabolism. When destructive and constructive metabolic processes balance each other the living organism remains stationary: this is characteristic of the mature organism. If assimilation is in excess of destruction growth ensues, if destruction is in excess of assimilation the living matter becomes less and death finally follows.

The second phenomenon associated with protoplasm is *Irritability*, or the power of responding to external and internal impressions, or *stimuli*. It is in virtue of this power that living matter is enabled to bring itself into relation with the world around it. The result of the irritability is seen in the power of movement or possessing sensation. In the higher animals special parts are set aside to receive these *stimuli*, and the animal is conscious of the impressions. This consciousness of an impression cannot be definitely said to exist in the lowest forms of life, but, on the other hand, neither can its existence be absolutely denied. The difference is only one of degree, not of kind.

Thirdly, living protoplasm, alone of all substances, is capable of *Reproduction*, of detaching parts of itself enabled to live independently as separate individuals.

The Work of a Single Cell. Here we come face to face with one of the most wonderful facts of Biology, namely, that all the functions which are necessary in order to constitute a living thing can be carried out by one single cell. The processes of nutritive metabolism resulting in growth, the manifestation of irritability in response to *stimuli* from without or within, and, finally, the power of reproduction, can all be seen in one minute simple mass of protoplasm, which because of these capacities is a living entity. Moreover, in the simplest of these *unicellular* organisms, whether they be regarded as plant or animal, any part of the protoplasm can perform any one of these functions. At one moment assimilation of nourishment is going on, at another moment a process of protoplasm called a *pseudopodium* is thrown out in response to some stimulus, and at a later stage this same protoplasm may be seen to detach itself from the mass and begin a separate individual existence capable as was the whole mass of all these functions.

All this is true of animal and vegetable protoplasm alike, and if the question be asked, "How does a plant differ from an animal ?" it follows that the distinction must be a somewhat artificial one, since the essential vital phenomena in both are identical. It is simple enough to tell a higher animal from a plant by reason of the possession by the animal of organs for locomotion and sensation, and because higher animals have a definite internal cavity for the reception and digestion of food. There is a definite difference in their *structure*. But the simplest one-celled animals and the lowest plants exhibit no essential difference in structure, and they can only be separated by the different ways in which they live their life, in other words, by differences in *function*.

Unity of Essentials. It is true that there is to a certain extent a chemical difference to be found between animal and vegetable cells, *albuminoids* being characteristic of animal cells, while *cellulose*, *starch* and *gum* occur more in the vegetable. *Chlorophyll*, the green colouring matter of plants, is very characteristic—in fact, any cell which has a covering of cellulose and contains *chlorophyll* within it is regarded as almost certainly vegetable. But the difficulty arises that both of these so-called characteristic vegetable substances are found in animals. Cellulose occurs in the covering of Sea-squirts, and a number of the lower fresh-water animals contain chlorophyll. It is also true that animals and plants agree in essentials as regards their methods of reproduction, and also in the way in which they exhibit relationship to the surrounding world. Not necessarily in detail, but in essentials. Organs of locomotion and organs of special sensation are, of course, more obviously present and more highly developed in animals, but it is a difference of degree merely, not of kind, and in the lowest animals and plants the difference is imperceptible.

But when we come to study the nature of the processes of nutrition in plants and animals we find there some real distinctions.

The Life-power of Plants. "Plants, as a whole, differ from animals in possessing the power of converting certain of the *inorganic* substances which occur, independently of life, in the earth and its atmosphere into the more complex *organic* substances which are found in living beings only. The *food* of plants consists of *carbon dioxide* (carbonic acid), ammonia, water, and certain mineral salts, these being, all of them, materials which occur in nature independently of life. As the materials composing the food of plants are all gaseous or liquid, or occur in solution in water, plants require no special aperture for the taking in (*ingestion*) of their nourishment. Out of these stable inorganic compounds the plant has the power of building up protoplasm and the other unstable organic compounds of which its tissues are composed. More especially, plants possess the power, denied to all undoubted animals, of breaking up or decomposing carbon dioxide, retaining the carbon of the same, and setting free the oxygen. For the exercise of this power, however, two conditions are requisite, *viz.*, the presence of sunlight and the existence in the plant-tissues of *chlorophyll*" (Nicholson).

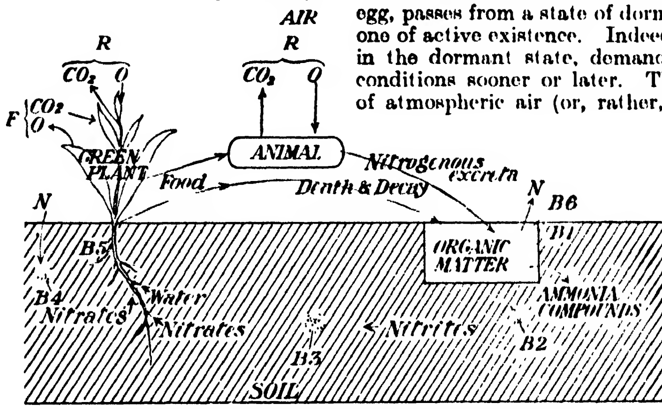
"Animals, in fact, differ from plants in requiring as food complex organic bodies, which they ultimately reduce to very much simpler inorganic bodies. The nutrition of animals is a process of oxidation or burning, and consists essentially in the conversion of the energy of the food into vital work, this conversion being effected by the passage of the food into living tissue.

"Plants, therefore, are the great manufacturers in Nature; animals are the great consumers.

"The *Fungi* are, however, economically speaking, animals. There are also various *carnivorous* plants (the Sun-Dew, Venus's Fly-Trap, etc.), which are genuine plants in so far that they can decompose *carbon dioxide* and build up starch, but which, nevertheless, have the power of digesting and absorbing ready-made organic materials in precisely the same way as animals do" (Nicholson).

Breathing. As regards the process, or function, of respiration it is essentially the same in all living tissues, plant or animal, but the two groups react differently upon the atmosphere. Both add carbon dioxide to the air as the result of breathing—animals by exhaling this gas into the air or water. In plants, however, respiration is much less energetic, and the carbon dioxide, as a result, much less in amount: and not only so, but this substance is actually employed by the plant as food. "Hence, during the day-time, the green parts of plants are constantly exhaling oxygen gas into the atmosphere, the evolution of carbon dioxide being masked or neutralised by the process of digestion. There is thus maintained an approximate uniformity in the amount of carbon dioxide present in the atmosphere. Animals, by their respiration, and by the decomposition of their bodies after death, are constantly adding carbon dioxide to the atmosphere, and at the same time are incessantly abstracting oxygen. Plants, on the other hand, during the day-time constantly remove carbon dioxide from the atmosphere, and add oxygen to it. Hence a balance is kept up, the members of each great division of living beings adding to the atmosphere the ingredients necessary to the life of the other" (Nicholson).

We are thus brought face to face with one of the most marvellous facts of biology, a fundamental principle which it is necessary to clearly understand at the very outset. It is Nature's unique plan of economising the energy of life, and the more its details are studied the more wonderful does it seem. Professor Ainsworth Davis's diagram, which we reproduce, is as simple as it is instructive [3].



3. THE RELATION OF PLANT AND ANIMAL LIFE

Arrows indicate the taking in or giving out of substances. Both green plant and animal take in oxygen [O] and give out carbon dioxide [CO_2] in respiration [R]. The animal feeds on plants, and by nitrogenous excretion and ultimate death adds to the store of organic matter in the soil. The green plant in feeding [F] takes in carbon dioxide [CO_2] from the air, returning oxygen [O], and also takes up water with dissolved salts from the soil; its dead parts contribute to the organic matter in the soil. The groups of bacteria [B1–B3] produce ammonia compounds, converting these into nitrites, and these again into nitrates. The bacteria [B4], and the tuberclefungi [B5], fix the free nitrogen [N] of the air, with production of nitrates. The bacteria [B6], in absence of oxygen, decompose organic matter with liberation of free nitrogen [N].

Dormant Life. So the active life of the world goes on, one process waiting upon another, every part of the complicated machinery doing its appointed piece of work. But even this is not all the marvel. In addition to the phenomena of active life, we find that there is a condition of cells which may be termed *Dormant Life*, in which it is impossible to say whether the cells are alive or dead, except that under certain conditions they manifest the phenomena associated with the active phase of existence. This dormant life is seen in the seeds of plants, and in the eggs of animals. In the cells composing these there is protoplasm, but no external manifestation of vitality, and under certain circumstances this absence of the evidence of life may persist for a very long period. In other words, certain environments are indispensable; they form the conditions of active life.

If these conditions are satisfied, the seed, or egg, passes from a state of dormant vitality into one of active existence. Indeed, life itself, even in the dormant state, demands some of these conditions sooner or later. Thus the presence of atmospheric air (or, rather, of free oxygen) is in an ordinary way essential to active life. The higher manifestations of vitality, again, are only possible between certain limited ranges of temperature, varying from near the freezing point to about 120° Fahr. Water, again, is essential to the carrying on of vital processes of all kinds. Hence the mere drying of an animal or plant will, in most cases, kill it outright, and will always suspend all visible vital phenomena.

Organised Life. Lastly, the great majority of living beings are *organised*—that is to say, they are composed of different parts or organs, which hold certain relations with one another, and which discharge different functions. It is not the case, however, that organisation is a necessary accompaniment of vitality, or that all living beings are organised. Many of the lower forms of life exhibit absolutely no visible structure, and cannot, therefore, be said to be "organised." Animals are organised, or possess structure, because they are alive; they do not live because they are organised.

It follows from this statement that some living things have ***absolutely no visible structure***

—that all the functions necessary to life, namely, nutrition, growth, reproduction, and functions of relation, can be carried out by one single cell, and this is one of the most marvellous facts in biology. Moreover, any part of that cell may be able to perform any one of these vital functions, or even all of them at different times. In a word, there is as yet in these simple forms of living matter no such thing as *Specialisation of Function*, which we see in higher forms. This is a point of very great importance and interest, because it is in the setting apart of special cells or parts of a cell for special work that is seen the first sign of the great process of evolution which ends in the characters of complicated and highly intelligent beings.

Vital Functions. A good example of a living creature performing all the vital functions in one single cell, each part of that cell acting with perfect indifference as a nutritive organ, a reproductive organ, or an organ of relation, is seen in the *unicellular Amœba*. Here no particular part of the protoplasm is set apart for any special work, there is no organisation and no specialisation of function. If an *Amœba* be watched under the microscope it will be observed to wrap itself around any minute particles which it encounters, by way of taking in nutriment. A little later the same protoplasm which absorbed the food particle will throw out a finger-like process (a *pseudopodium*) as a feeler, thus acting as an organ of relation. Still later, the same protoplasm actually divides itself into two, producing two complete individuals by a simple process of *fission*, or perhaps by throwing out a *bud*, which separates itself from the larger mass and floats off as a separate individual. Here the same protoplasm which had already manifested its power as an organ of nutrition and as one of relation now shows that it is also capable of performing the part of a reproductive organ.

Immortal Life. Now comes a great and wonderful thought. Since the original individual is by its division converted into two new individuals, it follows that in the history of a creature such as an *amœba* death is not a necessary phenomenon. In fact, we may truly say that an *amœba* is immortal. Its own protoplasm becomes that of its progeny by direct conversion of the parent into offspring. The parent is not everlasting, but it may be, and often is, deathless and in a real sense immortal. Besides all this, if we watched our amœba still further, we might observe it throwing out from its interior some particle which could not be assimilated, in other words, performing the function of excretion. By means of changing its shape and its *pseudopodia* it will move about; it has the power of locomotion, and, as is seen by its withdrawal from an irritating point, it possesses in some rudimentary degree what in higher forms we term *sensation*. This is the earliest sign of anything in the shape of consciousness that can be discovered. It cannot be asserted that a single cell has actually what we understand by that term, but, on the other hand, it cannot be denied.

So by the study of one of these simple *Protozoa* we find that every function which we recognise as necessary to Life can be performed by one single cell without any organisation or specialisation of its parts. We shall see later how this simple method of living becomes more complicated in higher forms, and how functions become separated from one another for the greater perfection and evolution of living things.

The Study of Living Beings. It is necessary now, in order that we may pick up all the threads of our subject in such a way that when put together they may form an intelligible whole, to ask ourselves, before proceeding further, from what aspects we can study living beings.

It is quite obvious from what has already been said, that every living being, whether animal or plant, can be studied from various points of view, each point of view constituting a special branch of biological research. We have traced our single cell until we find it is about to introduce us to more complicated beings, consisting of many cells with different functions, and before we are ready to enter upon that study, we must be quite clear about all that is involved in it. The question is: What are the various aspects in which a living being must be studied in order to see its life as a whole?

In order to answer this question, let the reader make use of the imagination, and picture to himself the position he would be in supposing he were fortunate enough to discover a new species of animal. The duty then devolves upon him of drawing up a description of his discovery in such a way that his readers may have a complete idea of its nature. He will probably find that the task of fully describing any one animal is quite beyond his powers. But we may suppose, for the purpose of our illustration, that the discoverer was competent to describe his discovery from every point of view. How would he do it? From what aspects can he approach the study of this creature in order to describe it fully? Some of these aspects are obvious. For example, he would state at the outset of his account what sort of creature he had found. His title would convey this much. His treatise would be headed "Discovery of a New Mammal" or "A New Species of Slug from Patagonia," or something similarly descriptive. If the latter title were the case in point, we see that we are introduced at once to two distinct aspects of the life of the new species. One is conveyed in the statement that it is a *slug*, the other in that it was found in "Patagonia."

Aspects of Study. How does the writer know that this new species is a slug? He can have arrived at that conclusion in only one way with certainty, namely, by studying the structure of the creature and finding that it was built up on the same lines as a number of other forms with which he was familiar and which were called *Slugs*. He has called it a slug on account of its *Morphology*, and from that aspect alone.

This aspect of study includes the general form and appearance of the animal, its shape, colour, possession of limbs, wings, fins, and other obvious external structures, or the absence of these. It includes in addition the study of the internal parts by means of dissection, and if necessary the study of the whole creature, or part of it, under the microscope. By such a study is determined the plan upon which the creature is built, and from its result the creature is placed among the mammals, birds, fish, molluscs, or wherever its place is.

But then, this creature with the structure of a slug was found in Patagonia. That is a statement which concerns its life-history from an entirely different aspect, namely, that of its *Geographical Distribution*, as far as it is known. It includes the investigation of the area which the species now inhabits and the conditions of its existence in those places.

The Life-history of a Slug. Passing from the two aspects of study suggested by the title of the treatise, the writer would then turn his attention to a number of other points of view. He would endeavour or observe and record how the animal lives its life, adapts itself to its surroundings, and discharges all its functions. This is an immense subject, concerning which we have already said something in the preceding pages. It is the aspect of *Physiology*, and it divides itself into the study of the three functions of nutrition, reproduction, and those directed to bringing the animal into relation with the world around it, as before indicated. There is much more involved in this aspect of life than at first sight appears, and as it is dealt with fully elsewhere we need refer no further to it here.

But these three aspects of description, though they would involve much labour, by no means exhaust the matter. Further investigation might lead to the discovery of the fact that this creature, though now so rare and restricted, was at one time of the world's history a much more common animal. If, instead of a slug the new species had been an animal with a bony skeleton, *fossils* might be found of the same character, which would indicate that Time had played a part in the life-history of the species, and this aspect of study, that of the past and present distribution of similar forms of life, is termed *Palæontology*, and presents some most interesting problems and no less interesting results. Thus a fourth aspect is described.

Specific Characters. But one aspect is no sooner dealt with than another claims attention. What is it that makes this animal different from all others, justifying its being regarded as a form new to science? It is a slug, but different from all the other slugs known to exist. What characters has it which are peculiar to itself? Some of its structures are common to all slugs and to some other animals, but there are some which no other animal possesses, and it is on account of these that the new discovery is recognised as a new species. This is the aspect of specific characters, by means of which the organism is classified.

Then there is a special study of the various changes in form and function through which an organism passes before it reaches maturity, a study which is partly of structure, partly of function, but which is now so large a science that it is taken up as a branch by itself, namely, that of *Embryology*.

Evolution. Finally, there is still one other point of view, perhaps the most interesting of all, a point of view which does not concern the living being as an individual, but which devotes attention to the investigation of the origin and history of groups of similar individuals, such groups as are termed species. It is a more or less philosophical aspect, one which studies the connection of one kind of animal with another, their relationships as well as their origin, their association as well as their probable destiny in the future.

This is the point of view of Evolution, the most fascinating portion of the whole of biology, largely a theoretical as well as a practical study. Evolution differs from other aspects of biology in this especially, that it takes no note of the individual, it refers entirely to groups; we do not speak of the evolution of *a man*, but of *man*—not of *a* horse, but of *the* horse, regarding men and horses as species of animals.

We see, therefore, that there are more aspects of the life of an animal than would at first sight appear, and a complete description must take up all these. It is practically impossible for any one man to make himself familiar with all that is known of all these aspects, even in relation to a very few animals. Each aspect is a study so far-reaching in itself that one of them is more than most students can learn thoroughly.

Seven Aspects of an Animal. The point is this, that it is of importance in describing an animal to remember that all these aspects must be considered before a complete description has been given. Of them all, the two most important from the standpoint of the ordinary reader are the aspects of structure and function, morphology and physiology; hence it is to these that we shall pay special attention here.

Summarising this, we see, therefore, that in order to give a fully complete description of an animal, the creature must be dealt with from the standpoint of its

Morphology or Structure,
Physiology or Functions,
Geographical Distribution,
Palæontology,
Classification,
Embryology,
and Evolution.

We shall see later that Physical and Mental Evolution proceed along similar lines, and must be studied by means of similar scientific methods.

To be continued

Group 8 **DRAWING** 2	# MODEL DRAWING, WITH PRACTICAL GEOMETRY **A First Lesson in Object Drawing. Measuring. Light and Shade. First Principles of Perspective. Instruments in Practical Geometrical Drawing**

By WILLIAM R. COPE

Model or Object Drawing. When a person wishes to make a drawing of any real object, he has many difficulties confronting him, which he did not have in freehand from the flat copy. He has now to give the representation of an object in the "round," on a flat surface of paper or canvas. Therefore his perceptive faculties will need still further careful guidance with reference to *how to see* an object, whether it be its apparent form, tone, or colour.

At present we shall deal chiefly with the apparent *form*, leaving tone and colour until the student is more advanced. It will be noticed that we have spoken of the *apparent* form of an object, and this is the first great stumbling-block to all beginners in object drawing. They so very often draw the *real* instead of the apparent shapes, and then cannot understand why their drawing does not appear like the object. There are so many optical illusions with regard to the appearance of an object, that, without a thorough method of explanation of *how to see*, the student is bewildered and sometimes gives up in despair.

Two Important Rules. There are several rules which will be helpful, but the two most important are:

1. Draw the *apparent* shape of an object, and not what you know is the *real* shape. Occasionally it happens that the *apparent* is the same as the *real* shape of an object, but still the above rule holds good.

2. In any objects, those edges which are *really parallel* to one another, and *recede from the spectator*, always appear to converge to some point.

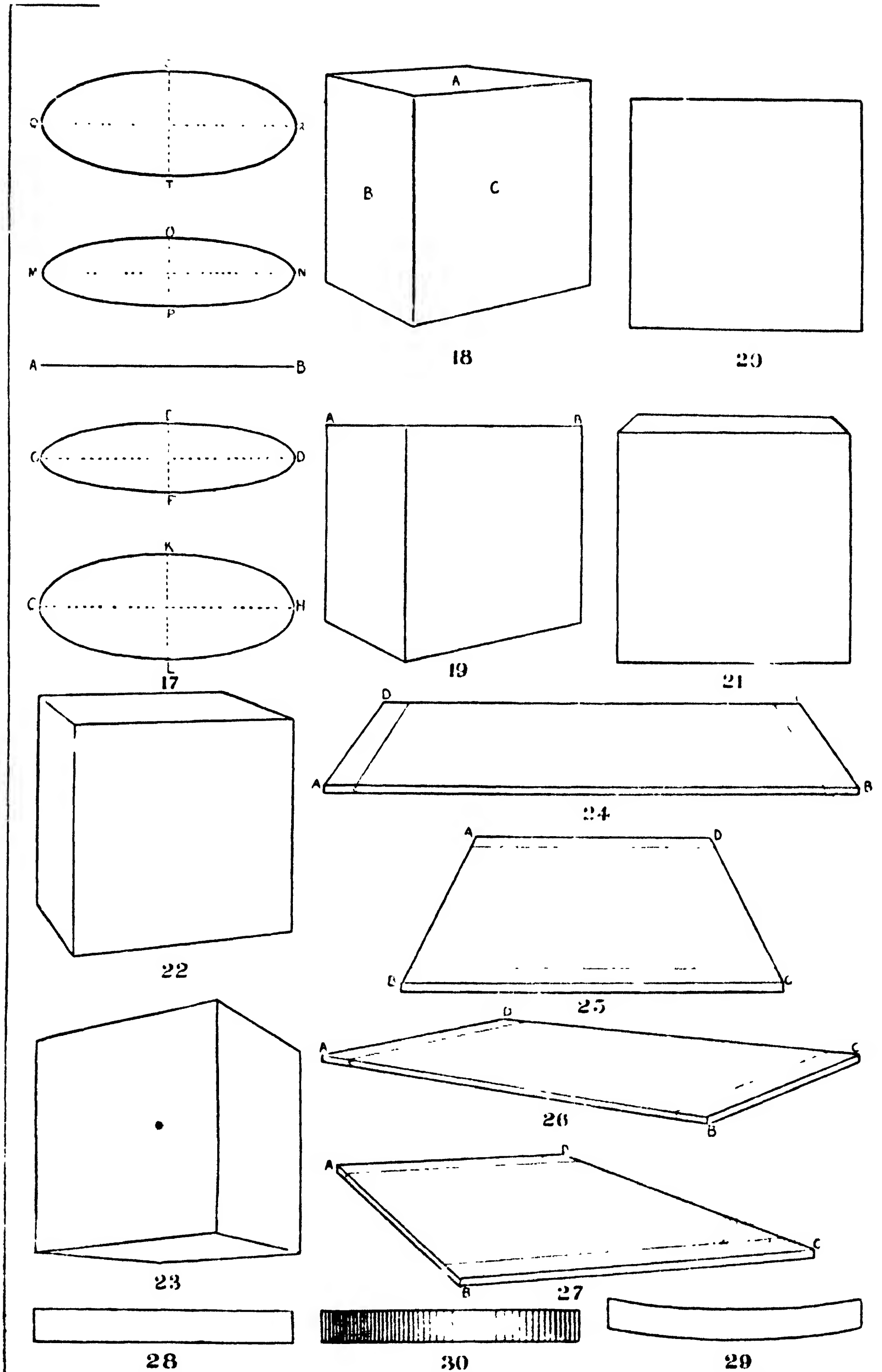
For explanation of the first rule we will take a circular hoop made of thin stiff wire, so that we can neglect its thickness. If the hoop be placed in a horizontal position on a level with the eyes, the student will see an appearance like *AB* in **17**. That is, a *straight* line must be drawn for the representation of a circle in such a position. This, to a beginner, is incredible at first, but he can easily prove that the apparent shape of the circle is a straight line, by holding horizontally, and on a level with his eyes, the straight edge of a ruler between his eyes and the object. He will observe that the real curve of the hoop *appears* to lie exactly straight and level with the edge of the ruler.

If the hoop be placed still in a horizontal position, but this time *below* the eye level, the student will see a shape like the ellipse *CFDE* in **17**. Here the distance *EF* is *apparently* much less than *CD*, but in *reality* they are equal. When the hoop is placed further below the eye, and still in a horizontal position, an ellipse of different proportion is seen as indicated in *GLHK* in **17**. Again placed in a horizontal position, but *above* the eye level, an ellipse like *MPNO* will be seen. Moreover, if the distance above the eye level is just the same as that below, and the hoop is exactly the same distance from the observer, this ellipse *MPNO* is the same size in every respect as the ellipse *CFDE*; but it must be remembered that the apparently upper curve *MON* now represents the *nearer* part of the loop, and *MPN* the *further* part, whereas, when below the eye level, *CFD* represents the nearer part, and *CED* the further.

If the hoop is placed higher still and horizontally, an ellipse like *QTRS* will be seen, and this will be exactly the same size as *GLHK*, if the respective distances, above, below, and from the eye are kept equal in each position. The student should also observe that the major axes *AB*, *CD*, *GH*, *MN*, and *QR* are always the same length, at whatever level (within the field of vision), if the hoop is placed at the same distance from the spectator, but the minor axes vary in length. The general tendency of all beginners is to make these minor axes too long.

The Cube. We will now take a cube as an example for more fully explaining the first rule. It is well known that each of its six faces is *really a square*, but it is, of course, quite impossible to see all these faces as squares at the same time; in fact, if we use an opaque cube, we cannot see, at the same time, more than *one* face as a *square*, and this only in a particular view. More often all the visible faces are nearly, but not quite, parallelograms. Look at **18** (which is the correct representation in outline of a cube when viewed from a particular point), and it will be seen that the faces *B* and *C*, more especially *A*, are not *squares* in this representation, for the angles are not right angles, the four sides of each surface are not equal, nor are certain pairs of opposite sides parallel. That is to say, by drawing the *apparent* shapes of *really* square surfaces, we obtain, as far as outline alone can give us, the true appearance of the object.

A real square face may even be represented by a line only, as for the top surface of cube in **19**, which is the appearance of the cube when placed upright, so that its top face is exactly level with the eye. In looking at **20**, we do not, at first, realise that it is the representation of a cube, but it is the appearance of it when it is placed in a vertical position, and the student is looking at it so that a straight line drawn from his eye to the centre of the visible face of the cube would be at right angles to that surface. He can thus see only *one* face of the cube, which *appears as a square* in shape. The student should now study other different appearances of the cube in various positions, as shown in **21**, **22**.



FIRST PRINCIPLES OF OBJECT DRAWING: DIFFERENT VIEWS OF CIRCLE, CUBE AND BOARD

and 23. The last figure is the appearance of the cube in a certain upright position *above* the eye level.

It often happens that a *short* line must be drawn for a *long* edge of an object, and a *longer* one for a short edge. Figures **24, 25, 26** and **27** are the outline representations of an ordinary drawing-board in various positions. In **25** and **27** it will be noticed that the *long* edges, *AB* and *CD*, of the board are drawn *shorter* than the *short* edges *AD* and *BC*. In certain positions these different edges may *appear* equal.

The eye is so easily deceived by what we *know* is the real length or size of an object, that our judgment is misled. Therefore we must have a means by which we can prove whether the judgment is correct or otherwise. The student must consistently persevere in first judging carefully with the eye alone, and afterwards test by measuring with a pencil held between the eye and the object. With regard to the method of holding the pencil for making tests, there are one or two important facts to be kept in mind, otherwise the test is worse than useless. The pencil must *always* be held at *full* arm's length, and at right angles to a line drawn from the eye to the object viewed.

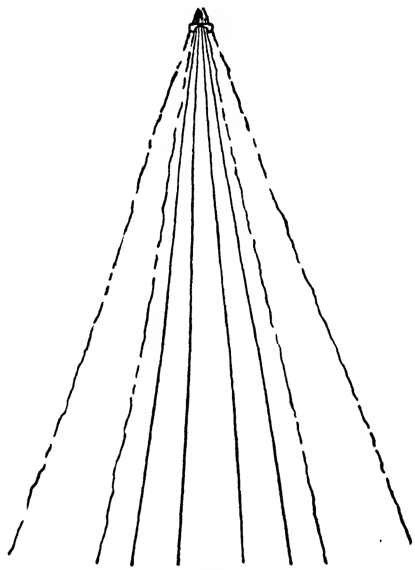
Measuring an Object. To be convinced of the necessity of this, the student should hold the pencil as just advised, and measure on it the apparent length of some horizontal or vertical straight edge, which is at some convenient distance from the eye; then, remaining at the same distance from the object, let him bend the arm a little, so as to bring the pencil nearer the eye, and measure the same edge again. He will find that its apparent length is now shorter than it appeared before. Again, let him bend the arm a little more, thus bringing his pencil still nearer to the eye, and once more measure the same edge. It will be found to appear shorter still. Thus the apparent length of the edge, as measured by means of the pencil, varies according to the distance at which the pencil is held from the eye. Therefore if, consciously or unconsciously, he holds the pencil at different distances from the eye, when comparing the apparent sizes of objects, he is making useless tests at different scales of measurement, he has no fixed standard, and is making the same kind of mistake as would be made by a person drawing a map of England, and using a different scale for each county, commencing with Northumberland at the scale of one inch to a hundred miles, then Durham at three-quarters of an inch to a hundred miles, Yorkshire at half an inch to a hundred miles, and so on. The map, of course, would be worse than useless for judging the relative sizes of the counties or distance from a town in one county to that in another.

It is very difficult to judge when the pencil is held at a *constant* distance from the eye when the arm is bent, but it is easy to know when the arm is at full stretch, and thus a fixed standard of scale is easily established for making accurate comparison of the relative sizes of objects.

Light and Shade. The light and shade which must necessarily be visible in any object, is a frequent cause of deceiving the powers of perception. Take a shape as represented in **28**. This appears to be an oblong, and, of course, is one; nevertheless, it is also the apparent shape, in outline, of a circular slab, when placed horizontally and on a level with the eyes. Beginners, because they *know* the slab is curved at its edges, draw the representation as in **29**, which is *wrong*. If **28** is shaded, as shown in **30**, the roundness is at once noticed, and yet the actual outline in **30** is an oblong as in **28**. Colour, too, will often deceive the eye with regard to size. A very light-coloured object surrounded by others which are very dark seems to the eye at first to be larger than it is found to be when tested by measurement with the pencil, and, *vice versâ*, a dark one appears smaller. To give the representation of certain objects in outline alone is sometimes more difficult than when rendered by tone and colour, but still these difficulties will be overcome if the student perseveres with the methods advised in this course.

Perspective. When we consider the second important rule of object drawing, we are brought face to face with the subject of Perspective, the theory and practice of which is almost invariably unknown to beginners in drawing. There are many capable artists who say that the rules of perspective are better left alone, but this is often only an excuse for not taking the trouble or not having the desire to study Perspective. The general principles can soon be learnt, and after some practical application of them, all students would do well to go through a good course of study, in which they can learn and practise the rules used in the linear and aerial perspective of objects with their shadows and reflections. It is certainly true that those students, who go through such a course thoroughly, will not only be able to make much more accurate judgment of the appearance of objects, but will also know *why* they must be drawn in a particular way in order to render a true representation of them. We shall confine ourselves to the most essential principles of perspective needed by all beginners in object drawing.

Everyone who has seen a railway or tramway, especially if it is straight, must have noticed that the really parallel metals *appear to converge* as they recede; see **31**, which represents a portion of a railway. It will be seen how well a suggestion of distance is obtained by making the lines converge. Now look at **32** (which is an *incorrect* drawing of the same railway); here we get no suggestion of distance, and the metals, etc., seem to be standing on end with the bridge placed on top. This apparent convergence is true of all parallel edges *which recede* from the observer. Whether they recede straight away in front of him [**33**], or slant away towards the right or left, or even upwards or downwards away from him, as long as they are *receding*, they will be observed apparently converging to



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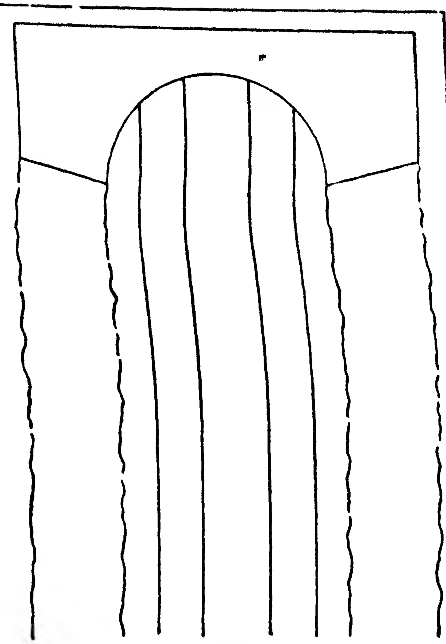

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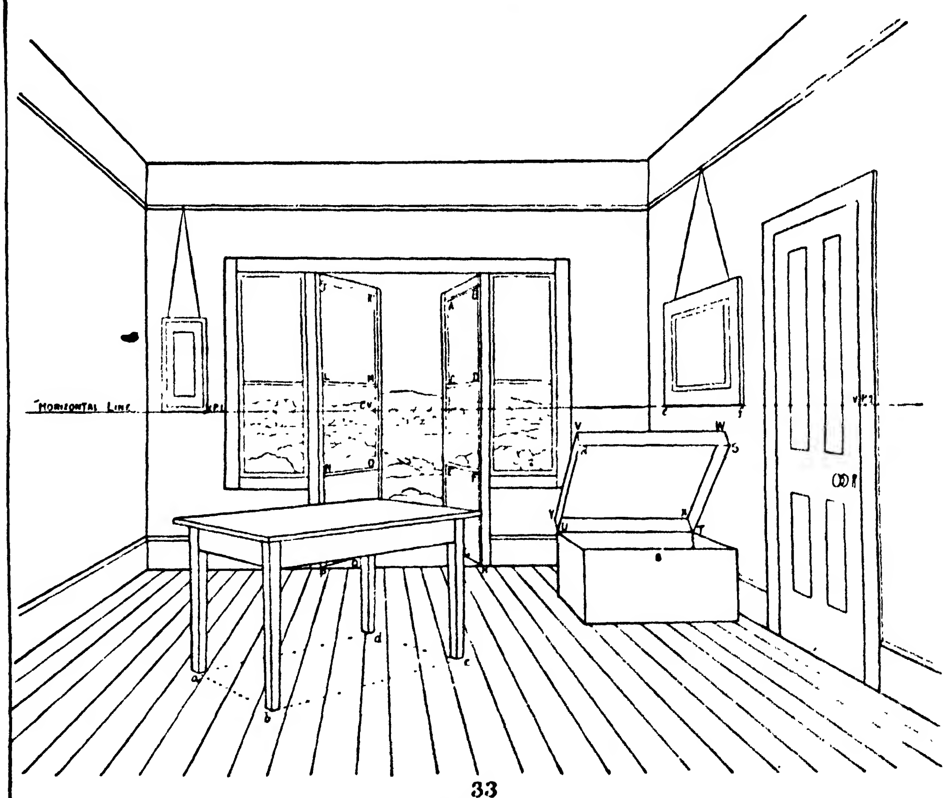


33

FIRST PRINCIPLES OF PERSPECTIVE RAILWAY AND INTERIOR OF A ROOM

some point, which, is technically called "a vanishing point."

The First Principle of Perspective. Thus we deduce the first principle of Perspective—*edges which are really parallel to one another, and recede from the spectator, appear to vanish to the same point.* In some cases this vanishing point is difficult to determine (unless the student knows the whole theory of perspective), but all *really* horizontal edges which recede *always have their vanishing point somewhere on the horizon line.* This horizon line is always supposed to be on a level with the eye, and its position in relation to other objects can easily be determined by holding perfectly horizontal, at arm's length, a piece of flat cardboard, so that only its *edge* is seen. The student can then see where it appears to cut the objects in view, and by careful observation he will find all receding parallel edges, which are really horizontal, appear to converge to some point on this horizon line.

Look at **33**, where the edges of the frieze and wainscot of the right- and left-hand walls, the floor boards, and certain edges of the door and one picture frame appear to converge to the point *C.V.* (*i.e.* the centre of vision, which is a point on the horizontal line directly opposite the spectator's eye). The edges *AB*, *CD*, *EF*, *GH*, of one door of the window, vanish to the left to *V.P.* 1; the edges *JK*, *LM*, *NO*, *PQ*, of the other door vanish to the right to *V.P.* 2; the long edges of the table, and the dotted lines *ad*, *bc*, on the floor, vanish to the right to *V.P.* 3 (which is outside the limits of the picture); the short edges of the table and the dotted lines *ba*, *cd* vanish to the left to *V.P.* 4, (which is outside the picture); in the lid of the box the edges *VY*, *RU*, *WX*, *ST*, vanish downwards to *V.P.* 5 (below the picture), while the edges *UY*, *RV*, *SW*, *TX*, vanish upwards to *V.P.* 6 (above the picture). It should be noticed that receding horizontal edges *above* the level of the eye appear to converge *downwards*, those *below* the eye level *upwards* to the horizontal line, while those exactly on the eye level, such as *ef* of the large picture, slant neither up nor down.

Parallel Lines. Particular attention should also be given to the representation of the edges of the frieze, top and bottom of window frame, and wainscot of further end of room, also the long edges of the box. It will be seen *they do not converge*, but are drawn perfectly horizontal and parallel, *because they are not receding* from the spectator. Further, upright parallel edges must be represented by *upright* lines, with no convergence for the same reason, see all the upright lines in **33**.

Keeping in mind the very important principles explained in the foregoing paragraphs, the student should now make many careful observations of objects around him, and endeavour to discern the difference between their *apparent* and *real* forms. He will then be well prepared to proceed in drawing some simple objects.

PRACTICAL GEOMETRICAL DRAWING

What Geometry Is. The term *Geometry*, which is derived from two Greek words (*ge*, the earth, and *metron*, a measure) originally signified *land-measuring;* but it now denotes the science of magnitudes in general, with their various properties and relations. We shall follow the *practical* side of Geometry, leaving the *theoretical* side to be explained in the lessons on Mathematics.

The student who possesses a knowledge of Euclid will have a powerful aid in understanding the principles used in practical geometry, and in remembering the methods of construction used in the various problems. We shall bring together those problems which depend for their solution upon some important geometrical truth, thereby not only training the mind to logical deduction, but aiding the memory.

Instruments Needed. The student should always work with the greatest possible accuracy and neatness, for, inaccuracy and slovenliness will undoubtedly lead to disappointment and failure. Whatever instruments are used should be of the *very best quality*, in order to avoid errors and vexation. The instruments need not be numerous, but the following are absolutely essential, and should be used for the purpose mentioned.

1. A half imperial drawing-board and pins, with its adjacent long and short edges perfectly perpendicular to one another.
2. A T-square, which is used for drawing lines parallel to the edges of the board [**34**].
3. Two set squares, having respectively angles of 45° and 60°. These are used to obtain perpendiculars and parallels [**34**].
4. A pair of compasses with movable pen and pencil legs (those with needle points are best, as they do not make large holes in the paper).
5. A pair of dividers for measuring.
6. A mathematical pen for ruling lines in ink.
7. Two pencils, one HH for the construction lines, and the other HB or F for the darker lines of the figure. It is best to sharpen them wedge-shaped, as the points last longer.
8. The paper may be cartridge for ordinary pencil work, but for inked drawings Whatman's or O.W.S. "hot-pressed" surface paper is the best.
9. A protractor, either semi-circular or as a flat ruler; see **35**, which shows how one is marked from the other. This is used for measuring angles in the following method: Suppose we wish to measure an angle of 50° at the point *A* in the line *AB* [**36**]. Place the point *C* of the protractor on the point *A*, carefully keeping the edge of the instrument on the line *AB*, and mark a point *D* opposite the division for 50°, remove the protractor and draw a line from *D* to *A*, then *DAB* is the angle required.
10. A foot ruler, with tenths of an inch marked on it, as well as the usual divisions, and also centimetres and millimetres.
11. Some Indian ink (in liquid form is best). Ordinary ink corrodes the pens.

To be continued

A DICTIONARY OF ELEMENTARY TERMS IN PLANE GEOMETRY

The figures after definitions refer to the illustrations in this section.

An **ACUTE ANGLE** is less than a right angle [44, EFG].

An **Acute-angled Triangle** has all its angles acute [53].

Adjacent Angles have a common vertex and one common arm. In 46, the angle ABC is adjacent to ABD.

Altitude of Triangle. See Triangle.

An **Angle** is the inclination of two straight lines which meet in a point, called the **vertex** of the angle.

The size of an angle does not depend upon the length of the lines forming it, but upon their inclination to each other. In 42 the angle BAC is the same size as the angle DEF.

The sum of all the angles in any one triangle is equal to two right angles, or 180°.

Apex. See Triangle.

An **Arc** is any part [ACB in 64] of the circumference of a circle between any two points in it.

Area. See Figure.

BASE. See Triangle.

To bisect means to cut into two equal parts.

CENTRE OF CIRCLE. See Circle.

A **Chord** is a straight line joining any two points in the circumference of a circle [AB in 64].

A **Circle** is a plane figure contained by one curved line, which is called the **circumference**, or **periphery** and is such that all straight lines drawn from a certain point within the figure to the circumference are equal to one another. This point [A in 63] is called the **centre** of the circle, and each of the straight lines [e.g. AB, AC, AD, AE in 63] is called a **radius** of the circle. The straight line [e.g. CD or BE in 63] drawn through the centre and terminated at both ends by the circumference, is called the **diameter**, which divides the circle into two **Semicircles**; and if two diameters are drawn perpendicular to each other, each of the four parts [CAB, BAD, DAE, EAC in 63] of the circle is called a **quadrant**.

Circumference. See Circle.

The **Complement** of an angle is the difference between it and a right angle. In 45 the angle ABD is the complement of the angle DBC, and DBC is the complement of ABD.

Concentric circles are those which have the same centre but different radii [66].

A **Curved line** is a line that is nowhere straight [39].

DECAGON, a ten-sided polygon.

Diagonal. See Quadrilateral Figure.

Diagonal Scale. See 107-109

Diameter. See Circle.

Duodecagon, a twelve-sided polygon.

An **EQUILATERAL TRIANGLE** has three equal sides [48].

Extreme and Mean Ratio. See 103.

A **FIGURE** is a space enclosed by one or more lines or boundaries, as 47-65. The sum of all the boundaries is called the **perimeter**, and the space within the perimeter is called the **area**.

HEPTAGON, a seven-sided polygon.

Hexagon, a six-sided polygon.

A **Horizontal line** is perfectly level [40 A].

Hypotenuse. See Right-angled Triangle.

IRREGULAR POLYGONS. See Multilateral figures.

An **Isosceles triangle** has two equal sides [49].

A **LINE** has length without breadth, and may be represented by various methods, as **thick, thin, dotted,** or **chain lines** [38].

MULTILATERAL FIGURES, or **polygons,** are figures contained by more than four straight lines [61-62]. **Regular polygons** have all their sides equal [61 and 62], and **irregular polygons** have their sides unequal [60]. Polygons are divided into classes according to the number of their sides; as, the

- **pentagon** [61], having five sides;
- **hexagon** [62], having six sides;
- **heptagon,** having seven sides;
- **octagon,** having eight sides;
- **nonagon,** having nine sides;
- **decagon,** having ten sides;
- **undecagon,** having eleven sides;
- **duodecagon,** having twelve sides.

A **Median.** A line drawn from the vertex of a triangle to the middle point of the opposite side.

NONAGON, a nine-sided polygon.

An **OBLIQUE LINE** is a line that slants [40 C and D].

Oblong. See Rectangle.

An **Obtuse angle** is larger than a right angle [44, HKL].

An **Obtuse-angled triangle** has one of its angles obtuse [52].

Octagon, an eight-sided polygon.

An **Orthocentre.** The intersection of the perpendiculars from the corners of a triangle to the opposite sides.

PARALLEL LINES are such as are in the same plane and never meet though produced indefinitely, but always retain a uniform distance apart [41].

Parallelogram. See Quadrilateral figure.

Pentagon, a five sided figure.

Perimeter. See Figure.

Periphery. See Circle.

Perpendicular. See Right angle.

A **Plane** is a level surface, and is such that, if any two points be taken in it, the straight line joining these two points lies wholly in that surface.

A **Point** has position only, without magnitude, and in practice is usually represented by a dot, as in 37.

Polygons. See Multilateral figures.

A **Problem.** A proposal to do something, such as to solve a question, or to draw a figure, as in 86-103.

A **Proposition** is that which is offered or proposed for adoption or consideration. Propositions are, in geometry, of two kinds, viz., **Problems** and **Theorems.**

QUADRANGLE. See Quadrilateral figure.

Quadrant. See Circle

A **Quadrilateral figure,** or **quadrangle,** is contained by four straight lines, as the square, oblong, rhombus, and rhomboid [54-57]. If the opposite sides are parallel, it is called a **parallelogram** [54-57]. The line joining two opposite angles is the **diagonal,** as AB in 54.

RADIUS. See Circle.

A **Rectangle,** or **oblong,** has its opposite sides equal and all its angles right angles [55].

Rectilineal figures are contained by straight lines, as 47-62.

Regular Polygons. See Multilateral figures.

A **Rhomboid** has its opposite sides equal, but its angles are not right angles [57].

A **Rhombus** has all its sides equal, but its angles are not right angles [56].

A **Right angle.** When a straight line meets another, so as to make the adjacent angles equal, each of the angles is called a right angle, and the lines are said to be **perpendicular** to each other. In 43 the angles ABC and ABD are each right angles, and the lines AB, CD are each perpendicular to the other. It should be observed that **perpendicular** does not mean upright or vertical, but **at right angles to another.**

A **Right-angled Triangle** has one of its angles a right angle. The side opposite this right angle is the **hypotenuse** [AB in 51].

A **SCALENE Triangle** has three unequal sides [50].

A **Sector** is a space enclosed by two radii of a circle [AB and AC in 65], and the arc BC between them.

A **Segment** of a circle is the space enclosed by an arc and its chord [64].

Semicircle. See Circle.

A **Square** has all its sides equal and all its angles right angles [54].

A **Straight line** is the shortest distance between two points.

A **Superficies,** or **surface,** is extension in two directions, and has only length and breadth, but no depth

The **Supplement** of an angle is the difference between it and two right angles. In 46 the angle ABD is the supplement of the angle ABC, and ABC is the supplement of ABD.

A **TANGENT** [A B in 66] is a straight line which touches a circle or curve at one point [C in 66] but does not cut the circle or curve when produced. A tangent to a circle is at right angles to the radius.

A **Theorem.** A proposition to be proved by reasoning.

A **Trapezium** has none of its sides parallel, but two may be equal [59].

A **Trapezoid** has only two sides parallel [58].

A **Triangle** is a figure contained by three straight lines. The side upon which it stands is termed its **base**; the point where the other two sides meet is its **vertex,** or **apex**; the angle at this vertex is the **vertical angle**; and the straight line which is drawn from the apex perpendicular to the base or the base produced is called the **altitude.** Thus in 47, if BC be the base, then A is the vertex, BAC is the vertical angle, and AD is the altitude. Triangles are named, with reference to their **sides**:

1. **Equilateral,** having three equal sides [48];
2. **Isosceles,** having two equal sides [49];
3. **Scalene,** having three unequal sides [50];

With reference to their **angles**:—

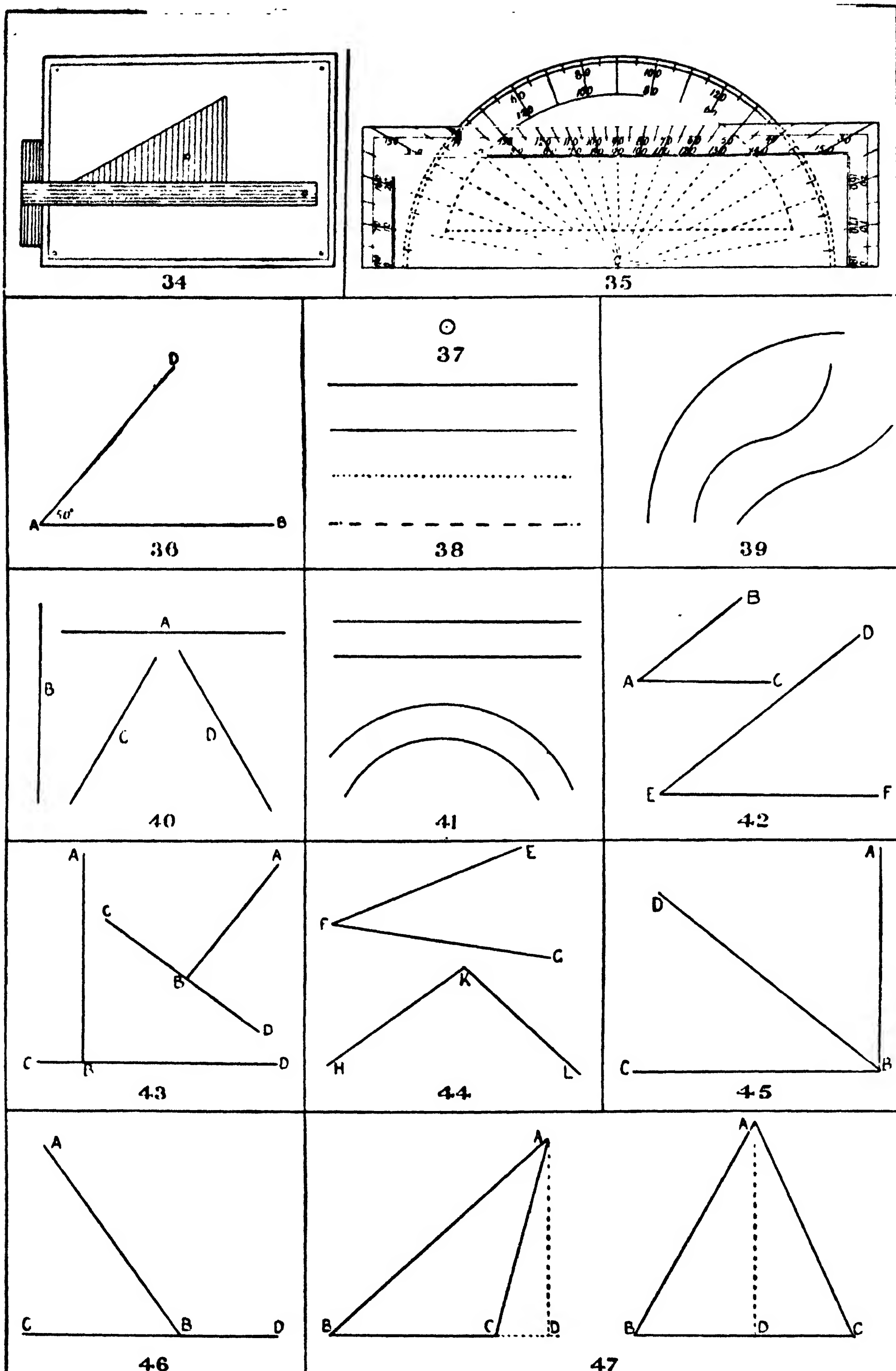
1. **Right-angled,** having one angle a right angle [51];
2. **Obtuse-angled,** having one angle obtuse [52];
3. **Acute-angled,** having all its angles acute [53].

UNDECAGON, an eleven-sided polygon.

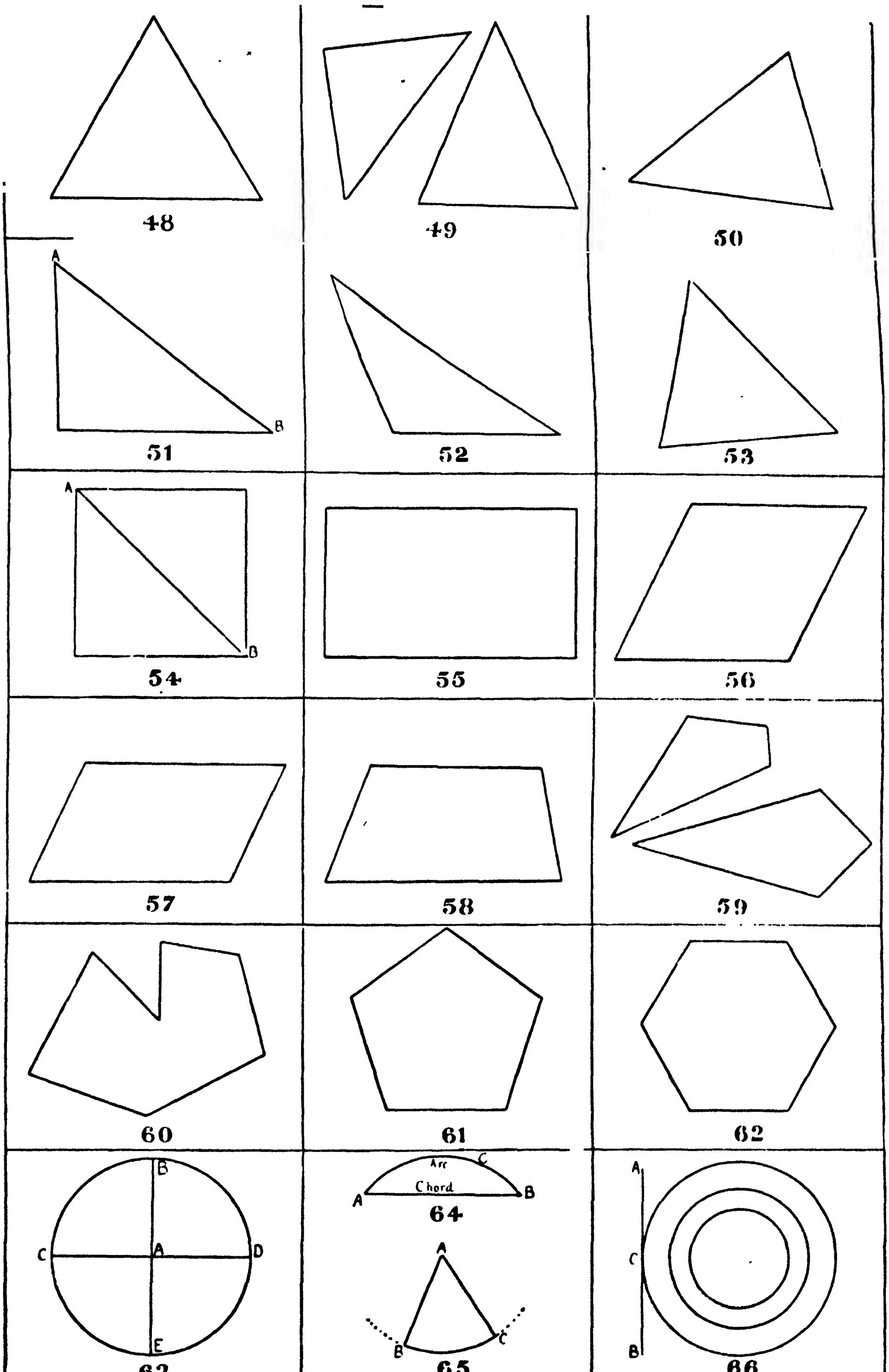
The **VERTEX** of an angle is the point at which the two lines which form the angle meet.

Vertical angle. See Triangle.

A **Vertical** line is upright [40, B].



PRACTICAL GEOMETRY: DEFINITIONS OF POINT, LINES, ANGLES, ETC.



PRACTICAL GEOMETRY: DEFINITIONS OF TRIANGLES, QUADRILATERALS, POLYGONS, CIRCLE, ETC

Group 10
ELECTRICITY
2

HOW ELECTRIC CURRENTS ARE GENERATED

Concerning Electricity. Its Chemical Properties. Conservation and Emission of Energy. Quantities of Energy and Energy of Motion

By Professor SILVANUS THOMPSON

TO make electricity of service it must be in motion. Our electric supplies are brought to our houses by copper wires or mains, as *currents*.

What precisely electricity is no one yet knows. Apparently it is not solid, liquid, or gaseous. It is invisible and imponderable. It appears to be of a nature different from matter. Matter, whether solid, liquid, or gaseous, possesses different properties when it is in motion from those it possesses when standing still. Matter, so long as it is at rest, can do no work for us, but when moving it possesses available energy. Electricity when at rest is not of the slightest use to mankind; but electricity in motion has many uses.

Generation of Electric Currents. Apparently electricity itself, whatever it may be, is as indestructible as matter. We can neither create it nor destroy it. It exists, usually neutral and inert, everywhere. But man has discovered means of setting it into motion, and of guiding it along conducting wires, and when there is a movement of electricity along a wire or around a circuit we describe such a flow of electricity as an *electric current*. There are many contrivances for setting up or *generating* electric currents; they are known as batteries, dynamos, magneto-electric machines, thermopiles and the like. None of them generate or create any electricity; what they do is to move some electricity which already existed, and set it circulating in the mains. Electric currents are themselves quite invisible; we know them only by the effects they produce. For example, any wire which is conducting an electric current is always more or less warmed by the current which it conveys. If we notice in our streets the places where electric mains are buried, we shall observe, particularly in winter-time, that the ground about them is slightly warmer than the rest of the soil. Snow melts sooner there, and moisture dries off there more rapidly. If a strong electric current is conveyed along a thin wire, that wire may be much heated, may even become red-hot, or be melted by the current. Our glow-lamps are illustrations of the heating effect of the current on a thin wire.

Chemical Properties of Electricity. Again, the conductor which is conveying a current is found to possess magnetic properties, which manifest themselves all round the wire as long as the current is flowing. A common magnetic compass placed over or under a wire that is conveying a current—even without touching the wire—will readily show the existence of this effect. The poles of the compass-needle are neither attracted nor repelled; but the effect of the neighbouring current is to tend to turn the compass-needle into a direction at right angles to that in which the current is flowing. Thus, if a current is flowing in a wire that lies from N.E. to S.W., and a compass is laid over the wire, the current in the wire tries to turn the needle so as to make it point in the direction lying from S.E. to N.W.

Again, if an electric current be led through water by means of wires that lead the current into the water at one side of the containing vessel and lead it out again at the other side—the two wires dipping into the water one at each side—it is found that the water will be chemically decomposed; and by suitable arrangements the constituent gases hydrogen and oxygen can be collected. Thus we see that the electric current possesses chemical as well as thermal and magnetic properties. So, if we can provide proper means for generating electric currents, and guide these currents by wires to the place where we wish to use them, we can cause them at will to produce heating effects—including the emission of light from the heated conductor—magnetic effects, and chemical effects.

Theories regarding Electricity. Although all this has been known for many years, and people are handling electric currents every day, the precise nature of an electric current is still unknown. Some authorities regard it as a flow of electricity inside the substance of the wire, flowing in one direction only, namely from the part called the positive terminal to the part called the negative terminal. More than twenty-five years ago the author gave numerous reasons for thinking that the real flow was, however, in the opposite direction. Others regard the current as consisting of two movements going on at the same time, something called positive electricity flowing in one direction along the wire, while an equal quantity of something called negative electricity flows in the opposite direction.

Another hypothesis is that the current consists solely of minute electrical atoms called "electrons," atoms of negative electricity, flowing through the substance of the copper wire from the negative to the positive terminal, that is in the opposite direction to that assigned in the usual conventions of writers on electricity. It is certain that whichever of these conceptions is true—and they may all be merely different verbal modes of expressing the actual electric movement—the transmission of the energy by the current takes place, not inside the conducting wire, but in the medium surrounding it.

Energy of Electricity. And this brings us to the all-important question of *energy*. For if the electric current is to transmit or convey energy along a wire—even if only to ring a bell—there must be some energy imparted to the electricity to enable it to perform the work required. In other words, before electricity can do anything for us, we must set it in motion—we must generate a current.

In electrical engineering, then, the first principle to be grasped is that of *energy*. Without the expenditure of energy no useful work can be accomplished. All dynamos are but machines for converting into electric energy the energy which is given to them by some prime-mover, a steam-engine, a gas-engine, or a turbine. All electric motors are merely machines for re-converting the electric energy, which they receive by means of the conducting wires or mains, into mechanical energy. All electric lamps are contrivances for converting into luminous energy a percentage of the electric energy that is supplied through the mains. All batteries are but little chemical apparatus to enable us to convert chemical energy into electric energy.

Conservation and Transformation of Energy. One of the greatest intellectual triumphs of the nineteenth century was the establishment of the doctrine of the conservation of energy. Energy can neither be created nor destroyed—it is as imperishable as matter. But it exists in many different forms in the so-called forces of nature, and is capable of being transformed from one kind to another. The sun radiates out to us vast quantities of energy in the form of light and heat. Plants and trees in their growth appropriate or absorb this energy and use it to build up wood out of the chemical constituents of air, earth and water, namely, carbon, hydrogen and oxygen. Coal is but fossilised vegetable matter—a store of energy drawn from the sun's light and heat countless ages ago. When we burn coal we set loose, in the act of chemical combination of the carbon and hydrogen in the coal with the oxygen of the air, the energy that was stored up in the coal, and transform it into the available form of heat.

When we wind up the weights of a clock we expend some of the energy of our muscles,—which we derived in turn by eating food—on doing this work. We *expend* the energy, but it is not lost; it is stored up as energy of position, or *potential energy* in the clock, which, as the weights descend, gradually expends it on driving the movement of the wheels, turning the hands, and keeping the pendulum swinging. When we wind up our watches we bestow a minute quantity of energy on coiling up the spring, and so store up enough to keep the machinery of the watch going for a day. Whenever a movement is forcibly produced against some actively opposing force, as when we raise a weight by exerting a force against the downward pull of the earth—which we call *gravity*—or when we coil a spring by exerting force against the tendency of the spring to recoil, we spend some energy. Another way of stating the thing is to say that we do some work. And, except for inevitable waste due to friction and like causes, the work we do in any such act is exactly the equivalent of the energy that we expend in doing it.

The Measurement of Work. Hence it comes about that we may measure energy, or express the amount of it, in terms of the equivalent quantity of work. A convenient unit in which to express the amount of work done in an operation is the *foot-pound*. This name is given to the amount of work that is done in raising a mass of one pound through a height of one foot against the downward pull of the earth. A pound is heavy only because the earth pulls it. If we could take the lump of iron called "one pound" to the moon it would there weigh far less than it does on earth, because the downward pull of the moon—which is a much smaller globe than the earth—would be far less than the downward pull of our sphere. And even at different parts of the earth's surface the "weight" or downward pull of a pound differs slightly. A pound weighs slightly less at the equator than it does in London, and as one goes toward the North Pole the weight of the pound—that is, the downward pull which it exerts because of the attraction of the earth—becomes slightly greater. This is because the earth is not a perfect sphere.

For precision, therefore, when we speak of the weight of a pound we shall mean its weight when in the latitude of London. And by one foot-pound we shall mean that amount of work which would be done by raising a pound through a height of one foot when the pound is being acted on by the same gravity as that with which it is acted on in London. Now, if we raise two pounds one foot high we obviously do twice as much work as if we raised only one pound—that is, we do two foot-pounds of work. Or, if we raise one pound two feet high we do twice as much work as if we raised it only one foot high; that is also two foot-pounds. So if we raise four pounds three feet high (against the action of gravity as in London) we do four times three, that is, twelve foot-pounds of work. If we raise 100 pounds six feet high, or 50 pounds 12 feet high, or 10 pounds 60 feet high, in each case we do six hundred times as much work as if we raised one pound one foot high—that is, 600 foot-pounds of work.

Quantities of Energy. Now, having got a way of expressing quantities of work, we can readily express quantities of energy in terms of the equivalent amount of work. It is found, for example, by experiment—it was the famous experiment of Dr. Joule—that in warming water the amount of energy that must be spent on a pound of water in order to warm it one degree (of the centigrade thermometer scale) is equivalent to 1,400 foot-pounds of work. It is found by experiment also that the quantity of energy stored up in a pound of good coal is capable, when converted into heat, of warming 7,400 pounds of water one degree, and is, therefore, equivalent to 7,400 times 1,400 foot-pounds; that is, it is equivalent to 10,360,000 foot-pounds

of work. Again, it is found by experiment that a cubic foot of dry steam at a pressure of 180 pounds to the square inch, and at a temperature of 192 degrees (of the centigrade thermometer scale) represents a store of energy of no less than 7,000 foot-pounds, though unfortunately no steam-engines are so perfect as to enable us to utilize the whole of this store. When the steam expands and cools—as it does in the cylinder of the engine or in passing through the blades of the steam turbine—it gives up this energy, or a great part of it, and so drives the machine. When water falls from a height it gives up the potential energy that has been put into it when it was raised up. The sun, by evaporating the seas and the moisture of the earth, raises up water as vapour and then deposits it as rain on the mountains. In doing so, it does a great deal of work—it winds up our waterfalls for us as we wind up the weights of our clocks. If a ton of water—that is, 2,240 pounds—falls down over a cliff 50 feet high it loses 50 × 2,240, that is, 112,000 foot-pounds of energy. But if we divert the falling water and let it fall down a pipe to turn the blades of a water-turbine for us, we shall be able to get from the turbine a large percentage—perhaps 90 per cent. of these 112,000 foot-pounds.

The Energy of Motion. There is another species of energy, namely, the energy of motion—also called kinetic energy—which is possessed by moving bodies. A moving body—a heavy rolling ball, a flying bullet, or a train in motion—possesses energy because it is in motion. It is known from the laws of motion that the energy possessed by a moving body is proportional to its mass and is also proportional to the square of the speed with which it is moving. If the mass be stated in pounds and the speed in feet per second, then the kinetic energy of the moving body can be calculated approximately by squaring the speed, multiplying the result by the number of pounds of mass, and dividing by 64 to bring it to foot-pounds.

Suppose a railway train to weigh 100 tons and to be moving at a speed of 50 feet per second, we may calculate the inherent energy which it possesses as a moving body as follows: The square of 50 is 2,500. The 100 tons are 224,000 pounds. Multiply 2,500 by 224,000, and divide by 64, and we get as the answer 35,000,000 foot-pounds. That is the amount of energy that is in that moving mass: it is the amount of energy that it would expend if it were to be suddenly stopped as in a collision. That is the amount of energy that will be wasted, as heat, in the brakes, if we bring it to rest by putting on the brakes. That is the amount of energy that we should have to put into it to start it again up to full speed.

Power. Another fundamental point in engineering is the precise idea and definition of *power*. Power is the rate at which energy is being spent, or the rate at which work is being done. Suppose a man to be working so hard as to be doing, say, 50 foot-pounds of work per second. He might easily do this by turning the handle of a winch raising 50 pounds a foot high in each second of time. But suppose he is only working half as hard, then the power he is exerting is only 25 foot-pounds per second. More than a century ago James Watt made experiments to find out the rate at which, on an average, during an average shift of work, a horse does its work. He fixed, as a convenient expression, the amount of 550 foot-pounds per second as the value of one horse-power. This is, of course, the same rate as 1,100 foot-pounds in two seconds, or 33,000 foot-pounds per minute, or 1,980,000 foot-pounds per hour. Everyone knows that a horse when stimulated by the whip can exert a much greater power for a short time than it can exert continuously on the average day's work. In fact, a horse can for a few minutes exert five or six horse-power. Similarly a man can for a few seconds at a time exert as much as one horse-power.

The Horse-power. If power, then, is the rate of doing work, it follows that if we multiply the power by the time that it lasts we shall have an expression for the amount of work done during that time. So if a horse-power be 550 foot-pounds per second, then if any engine works at the rate of one horse-power for 300 seconds (=5 minutes), it will by the end of that time have done 550 × 300, that is, 165,000 foot-pounds of work. Or, if it goes on giving out a horse-power for an hour (=3,600 seconds) it will have done 550 × 3,600, that is, 1,980,000 foot-pounds.

Now it is not always convenient to have to use such large figures. For example, if we had to express in foot-pounds the result of 80 horse-power supplied for a week, the figures would be unmanageable. For many purposes, therefore, it is more convenient to think of the amount of work done by a horse-power working for a whole hour (we have just seen that it amounts to 1,980,000 foot-pounds) and simply call it *one horse-power-hour*. Then, since a week contains 7 × 24, or 168 hours, it follows that 80 horse-power supplied continuously for a week would mean a total amount of work done of 80 × 168, that is, 13,440 horse-power-hours.

The Kilowatt. As will be explained in due course, electrical engineers deal with another unit of power called the *Kilowatt* (see ELECTRIC MEASUREMENT). It is about 1⅓ times (or, more precisely, 1·3404 times) as great as the horse-power, for 1,000 horse-power equal 746 kilowatts. In other words, a horse-power is about ¾ of a kilowatt. In fact, while a horse-power is 550 foot-pounds per second, or 33,000 foot-pounds per minute, a kilowatt is 737·2 foot-pounds per second, or 44,232 foot-pounds per minute. If an electric generator is giving out power at the rate of one kilowatt, it will at the end of one minute have delivered electric energy equivalent to 44,232 foot-pounds. Or at the end of an hour, at the same rate, it will have delivered a total amount of energy of 2,653,920 foot-pounds.

Now, this power at the rate of one kilowatt being for one hour's duration, we may call the total amount of electric energy one *kilowatt-hour*. It is usual in commercial dealings concerning electric energy to express amounts of electric energy in *kilowatt-hours*. Indeed, under the Electric Lighting Act of 1882, this amount of energy is described as one "Board of Trade unit," or in ordinary usage one *unit* of electric energy. When that Act was passed the persons or companies supplying electric energy were forbidden to charge as their maximum price more than 8d. per unit, that is 8*d*. per kilowatt-hour. Since that time the price of electric energy has been greatly cheapened, so much so that the great electric power supply companies can supply electric energy to manufacturers at less than 1*d*. per kilowatt-hour. In most towns the supply of electric energy for lighting is usually 4*d*. or less per kilowatt-hour. Where water-power is available, the manufacturers can get electric energy far cheaper, even down to 0·04 of 1*d*. per kilowatt-hour.

We have seen that the kilowatt is about 1·34 times as great as the horse-power; hence the kilowatt-hour—or *unit*—is equal to 1,034 horse-power for one hour. Or one horse-power for one hour is equal to 0·746 kilowatt-hours—or units. It is, therefore, a simple calculation how much a supply of power at the rate of one horse-power ought to cost per annum if the price be, say, 1*d*. per unit. For there are $24 \times 365 = 8{,}760$ hours in a year—reckoning day and night continuously. Hence one horse-power-year equals 8,760 horse-power-hours; or, multiplying by 0·746, equals 6,535 kilowatt-hours, which at the rate of 1*d*. per kilowatt-hour is a total cost of 6,535 pence, or 54·46 shillings, or £27 9*s*. 2½*d*. Manufacturers who might not care to give £27 9*s*. 2½*d*. per annum for one horse-power, running day and night, would probably readily give £10. So if energy can be supplied at as low as ¼*d*. per unit, it will be cheaper to use electric power than to erect small steam-engines in factories.

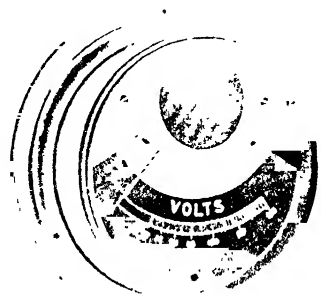
The Essentials—Effort and Movement. Now, before we discuss either batteries or dynamos in detail, we have one other point to make clear. In all cases where power is developed, whether mechanically or electrically, there are two factors to be considered. In the mechanical case one factor is, so to speak, *effort*, the other is quantity of *movement*. There is no power delivered unless both factors exist; and the power is their product. Thus the power delivered by a belt running from one shaft to another depends not only on the pull of the belt, but on the speed at which it is running. If in some particular case the belt-pull is, say, 100 pounds—that is, the tight side pulls 100 pounds more than the slack side—yet it yields no power unless the belt is running. If that belt is running at, say, 3,000 feet per minute, then the power which the belt is transmitting is $3{,}000 \times 100$, that is, 300,000 foot-pounds per minute, or (dividing by 33,000) is about 9 horse-power. If a belt run ever so fast it transmits no power unless there is also the force or effort at the same time: and, be the effort never so great, it delivers no power unless the quantity factor exists also. Electric power also consists of two factors, an effort-factor and a quantity-factor. The electric current, in fact, conveys no electric power unless there is an electric effort present to keep it going.

The Ampere. Names are needed to express these things. Electricians have adopted such names. The amount of a current, sometimes called the quantity of the current, that is flowing, is expressed in terms of a certain unit called one *ampere*. "One ampere" denotes a particular quantity of current defined (by an Order in Council) by the law of England (see ELECTRIC MEASUREMENT). An *amperemeter* (or ammeter) is an instrument [8] which if inserted in an electric circuit will indicate at any instant by the pointing of a hand to a scale the quantity of that current, or, as some people would say, will show how strong the current is. The amperemeter tells nothing about the effort factor, it deals with the quantity only: and a current may be great, of many amperes, and yet deliver very little power, unless there is an effort-factor existing to push the current along. This other factor, the electrical effort with which the current is urged along, has received from electricians several different names. Some call it the electric *pressure*, others the *electro-motive-force* (or tendency to move electricity), others again the electric *potential*. It matters little which name is used if only the thing itself is rightly understood—it is an electrical effort that tends to move the electricity along, tends to drive the current, does, in fact, drive it along, if there is a proper circuit. In some cases, as we shall see, there is an electric effort or electro-motive-force exerted in an opposite direction to a current, and in such cases tends to stop it—just as a resisting effort may occur in a piece of revolving machinery.

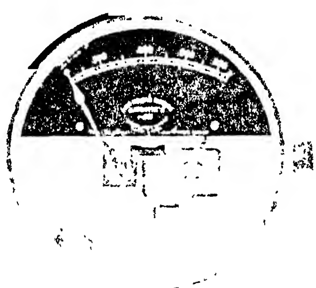
The Volt. The amount of any electric effort, or electromotive-force (whether it be driving the current or opposing the current) is expressed in terms of a unit called one *volt*. "One volt" denotes (again by legal definition, for which see chapter on ELECTRIC MEASUREMENT) a certain definite amount of electric pressure or electro-motive-force. A *voltmeter* [1] is an instrument used to measure the electric pressure, or electro-motive-force, or potential, or *voltage* (all these names are used, and all mean the same thing, namely, *the number of volts*), which has been applied to, or is being generated in any circuit. The mains for house-lighting are usually supplied at a pressure (in cities) of 200 or 220 volts. In private lighting the pressure is more often 100 volts. For tramways a pressure of 500 to 550 volts is usual. For long-distance electric transmission of power extra high voltages of 6,000, 10,000, 20,000 and even 50,000 volts are used. Single voltaic cells have, as we shall see, low voltages of one to two volts only: so to get higher pressures by means of cells we have to arrange a number of them as a battery. Thus, if a Daniell's cell has a voltage of 1·1 volts,

to get by means of such cells a pressure of 100 volts we should have to arrange 91 of them as a battery of cells, all joined up in series. A Daniell's battery to give 1,000 volts would require a row of 909 cells in series.

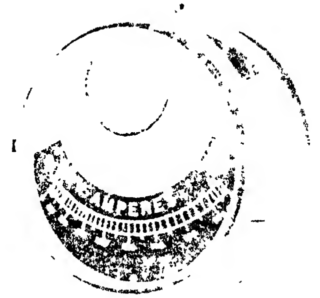
The Watt. Now, when any electric system supplies electrical energy, whether in heat, light, or any other form, the electric power so supplied is the product of the two factors—the number of *amperes* of current, multiplied by the number of *volts* of pressure at which the amperes are supplied. Again, a name is required for the product. If one ampere of current were supplied at a pressure of one volt, the product might be called one *volt-ampere ;* the word being built up just in the same way as the word foot-pound is made to denote the work done in raising through one foot against the downward gravitation force of one pound. But, though the word *volt-ampere* is sometimes so used to denote the unit of electric power (that is the rate at which electric energy is being supplied), electrical engineers more often give another name to this unit, namely one *watt.* "One watt" denotes by legal definition the amount of electric power which is brought by a current of one ampere flowing under a pressure of one volt. A *Wattmeter* [2] is an instrument which can be directly attached to a circuit to indicate the value in watts of the power that is at any moment being supplied. For the construction of a wattmeter the reader is again referred to ELECTRICAL MEASUREMENT. Let us illustrate the matter further by an example. If in some house there are 85 glow-lamps alight, taking on the average $\frac{1}{4}$ ampere each, and if the pressure at the electric mains is 200 volts, how many watts of power are they taking? The amperes will be $\frac{1}{4}\times 85$, that is, $21\frac{1}{4}$: to find the watts we must multiply the volts by the amperes, namely, multiply 200 by $21\frac{1}{4}$; so that the result is 4,250 watts. That is what a wattmeter would indicate as to the electric supply to those lamps. As the numbers of watts often run into thousands, electricians have adopted the term *kilowatt* to denote 1,000 watts. Hence the power taken by the 85 lamps in question, when all are alight, would be called 4·25 kilowatts.



1. VOLTMETER



2. WATTMETER



3. AMPEREMETER

As the *watt* and the *kilowatt* are units of electric power, they can be compared as to their value with the mechanical unit of power mentioned earlier in this chapter, namely, the horse-power. It can be shown from first principles that one horse-power is equal to 746 watts, or one watt equals $\frac{1}{746}$ of a horse-power. And as one kilowatt is 1,000 watts, it follows that one kilowatt equals 1·3404 horse-power; and that one horse-power equals 0·746 kilowatt. The 85 lamps mentioned will be receiving electrically 5·7 horse-power.

The Kilowatt-hour. If electric power is being supplied the total energy given thereby will be the product of the power and of the time during which the power is supplied. Now, the legal "unit" of electric energy in this country is the *kilowatt-hour.* The electric-lighting companies charge their consumers according to the number of kilowatt-hours of energy they have consumed. They put in meters to measure the amount of consumption, and charge, some *4d.*, some *3d.*, in some cases less, per kilowatt-hour. Suppose, in the case of the 85 lamps used as an example above, taking power at the rate of $4\frac{1}{4}$ kilowatts, the price of the supply was *4d.* per kilowatt hour; then to keep all these 85 lamps alight will cost the consumer $4\times 4\frac{1}{4}$, that is 17 pence per hour. If he has kept them alight on an average three hours a day, then when quarter-day comes his meter will have registered 1,163 kilowatt-hours (or "units"), and at *4d.* per unit his bill for the quarter will be £19 *7s.* *8d.* When electric energy is supplied in bulk to factories from central generating power-houses, the price is usually under *1d.* per unit. Suppose a manufacturer takes 100 amperes at 5,000 volts pressure, that is, takes electric power of 500,000 watts, or 500 kilowatts; and suppose him to use that power for 3,000 hours (*i.e.* an average of 10 hours per day for 300 days) in the year; suppose also that the price charged is $\frac{3}{4}d.$ per unit; then his power will cost him $500\times 3000\times\frac{3}{4}$ = 1,125,000 pence, that is, £4,687 10*s.* per annum. And as he is getting over 670 horse-power, his supply is costing him under £7 a year for each horse-power supplied.

To be continued

Group 13
GEOGRAPHY
2

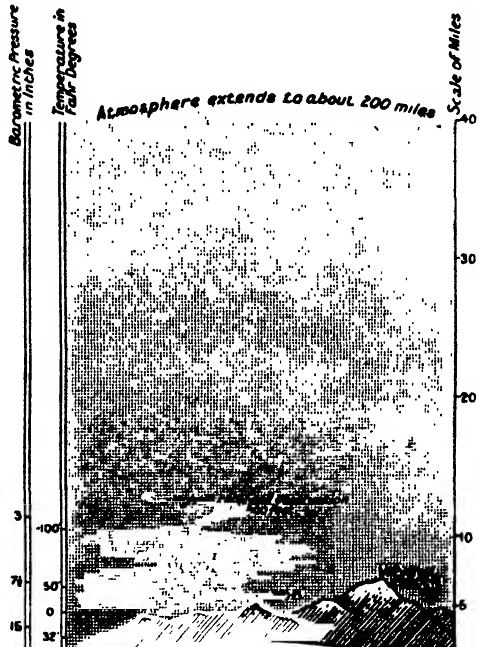
THE CLIMATES OF THE WORLD

The Atmosphere. Rainfall and Its Distribution. Why and When it Rains. The Wind System. Heat and Cold. Temperature of the Air.

By Dr. A. J. HERBERTSON, M.A., and F. D. HERBERTSON, B.A.

BY June 21st the sun is vertically overhead at 23½° N. lat., the *tropic of Cancer*, and its rays reach 23½° further north than they did at the spring equinox, when they just reached the pole. Consequently, within a radius of 23½° round the North Pole—that is, within the *Arctic Circle*—the sun does not drop below the horizon, but is more or less completely visible at midnight. At the tropic itself the sun's rays fall vertically, and more nearly so north of it than at any other part of the year, so that they have their greatest heating power. It is the *midsummer* of the northern hemisphere. In the southern hemisphere, on the other hand, which is at that part of the earth's orbit where it is tilted from the sun, it is *midwinter*. The sun's rays are falling as nearly horizontally as they ever do. Within a radius of 23½° round the South Pole, within the Antarctic circle, they are hardly felt at all. At the South Pole itself it is midnight, the middle of the six months' night which alternates with the six months' day.

After June 21st in the northern hemisphere the sun appears to turn south. The point at which it is vertical at noon begins to recede towards the equator, where the sun is again overhead on September 21st, the *autumn equinox*. Its rays again just reach both poles, making day and night equal. Thereafter the night of the northern hemisphere lengthens and its day shortens, as the sun's rays strike it more and more obliquely. The reverse is true in the southern hemisphere, where the rays are falling more and more vertically, and further and further towards the South Pole. The vertical noon point continues to recede south of the equator till December 21st, when the sun is vertical over the tropic of Capricorn, 23½° S. It is now midsummer in the southern hemisphere, midday at the South Pole, midwinter in the northern hemisphere, and midnight at the North Pole. Then the sun apparently turns north again, and is once more vertical over the equator at the spring equinox, March 21st.



13.

SECTION OF THE ATMOSPHERE

The temperature and the pressure or weight of the atmosphere decrease as the elevation increases.

The student will hardly need to be reminded that this shifting of the point at which the sun is vertical at noon is due to change in the earth's position relatively to the sun, and not to the movement of the sun.

Heat and Light. It is customary to distinguish various *zones*, or *belts*, on the earth's surface according to the amount of light and heat they receive from the sun.

Between the poles and the polar circles are the *frigid zones*, with one long day and one long night at the pole, and elsewhere almost continuous daylight in summer, and almost continuous darkness in winter. There are only two seasons — winter and summer.

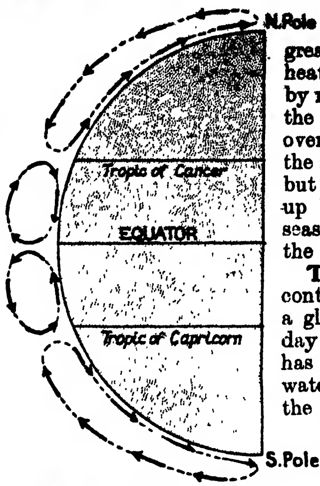
Between the polar circles and the tropics—that is, between the parallels of 66½° and 23½°—are the north and south temperate zones, with long winter nights and long summer days. Besides winter and summer they have the intermediate seasons of spring and autumn.

Between the tropics and the equator are the north and south torrid zones. Here the sun is vertical twice a year, except on the tropics, where it is vertical once. There is no winter.

The belt of greatest heat swings north and south of the equator with the sun, but the equator is always in it. It extends furthest north in the northern summer, when the sun is vertical over the northern tropic, and the northern hemisphere is tilted furthest towards the sun, and furthest south in the southern summer, when the sun is vertical over the southern tropic, and the southern hemisphere is tilted furthest sunwards. The effect of this variation on the distribution of rain and winds is very important, and the fact must be carefully borne in mind. The temperate and frigid belts oscillate similarly.

Of the moving world on which we live we know only the surface. This consists of solid land and liquid water, both visible to sight. Our sense of touch assures us of something more, which we cannot see, but which we feel as breeze or wind. This is the atmosphere, the envelope of air which surrounds the earth, held to it by the force of gravitation, and moving with it on its daily and yearly journey. Without the atmosphere life would be impossible for plant or animal, for neither could breathe.

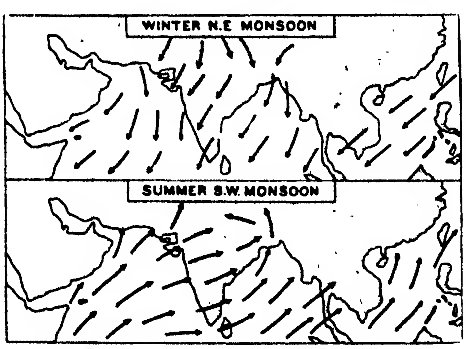
At the surface of the earth, where the force of gravity is most strongly felt, the density of the air is greatest—that is, the particles are most closely packed. As the force of gravity diminishes with the increasing distance from the centre of the earth the atmosphere becomes less and less dense, and at the height of a few thousand feet climbers suffer severely from want of air. [For the composition of air, see CHEMISTRY.] The weight of the envelope of air is measured by the barometer. [See PHYSICS.] It naturally decreases with elevation, and the barometer falls.



14. CIRCULATION OF THE ATMOSPHERE

This diagram shows the theoretical movement of the air between the Equator and the Poles.

Temperature of the Air. Experience tells us that the air is hot in summer and cold in winter. These changes, however, occur only near the earth's surface. The atmosphere allows the rays of light and heat from the sun to pass through it, but is little affected by them, except in the lower, denser layers. About one-third of the solar heat is absorbed by the atmosphere. The remaining two-thirds reach the surface of the earth, from which the layers of air in contact with it receive most of their heat. The temperature of the air is highest close to the earth's surface, and diminishes rapidly away from it. The upper layers of the atmosphere are always cold. Self-recording instruments have been sent up in balloons, and they register up to 100° frost at a height of a few miles [18]. On the top of a high mountain, whether in winter or summer, it is cold unless the sun is shining. The warming surface is reduced by the tapering of the mountain, and the temperature of the surrounding air is therefore but little raised. Nevertheless, it is slightly warmer than air at the same height above a plain, as it is in contact with a small part of the earth's surface.



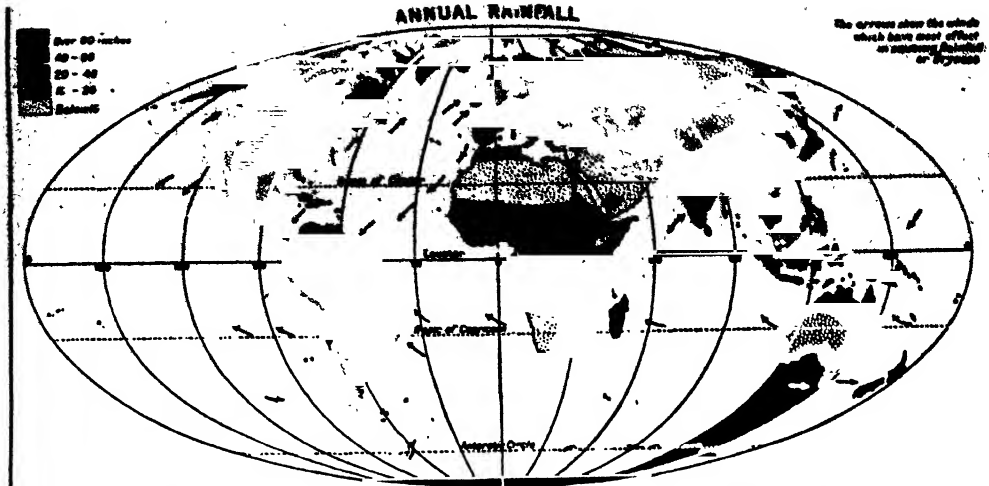
15. THE MONSOONS, OR SEASONAL WINDS OF SOUTHERN ASIA

The earth, then, is always receiving heat and always parting with it. A great part of the heat it receives it radiates back. Land and water differ considerably in their capacity for storing heat. Land absorbs heat more quickly, but the heat does not penetrate far below the surface. Water, though heated more slowly, is heated to a much greater depth by the motion of its heated particles, and it loses heat by radiation much more slowly than the land. The land and the air over it are consequently hotter than the sea and the air over it in summer, but the sea retains more of its stored-up heat on into winter, at which season the air over it is warmer than the air over the land.

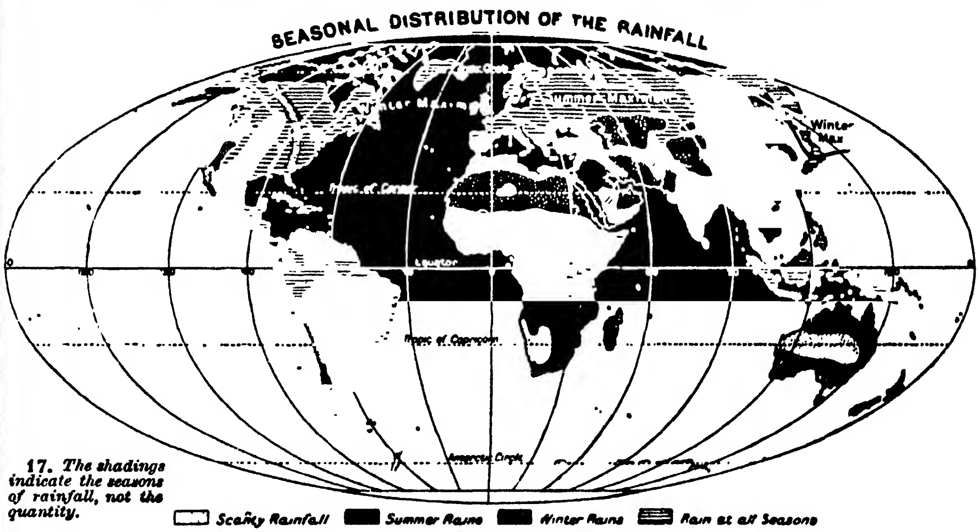
The Cause of Rain. The air contains invisible water vapour. If a glass of water is spilled on a hot day the water quickly dries up. It has been converted by heating into water vapour, and has passed into the atmosphere. The same process takes place on a cold day, but much more slowly. This process of conversion into vapour is called evaporation. The surface layers of water are always evaporating, slowly or quickly, according to the temperature of the air. When air is dry and hot it takes up vapour very quickly and holds a large quantity. When it can hold no more it is said to be saturated, or to have reached the saturation point. This saturation point differs at different temperatures. Air at a high temperature can hold much more water vapour without becoming saturated than air at a low temperature. If the temperature of saturated air is lowered it must part with moisture till it reaches the saturation point of its new temperature. This surplus moisture returns to the liquid form and falls as rain. A familiar illustration may make this clearer. If the hand is placed on a mirror the glass is at once covered with mist. The moisture which was invisible on the hot hand is chilled by the cold glass to the point at which it becomes liquid and visible. This process is called condensation.

The distribution of rain, therefore, depends on air passing from hotter to colder regions—that is, on the wind system of the globe.

The Wind System. We saw that in the equatorial regions there is a hot belt which moves north of the equator when the northern hemisphere is tilted towards the sun, and south of it

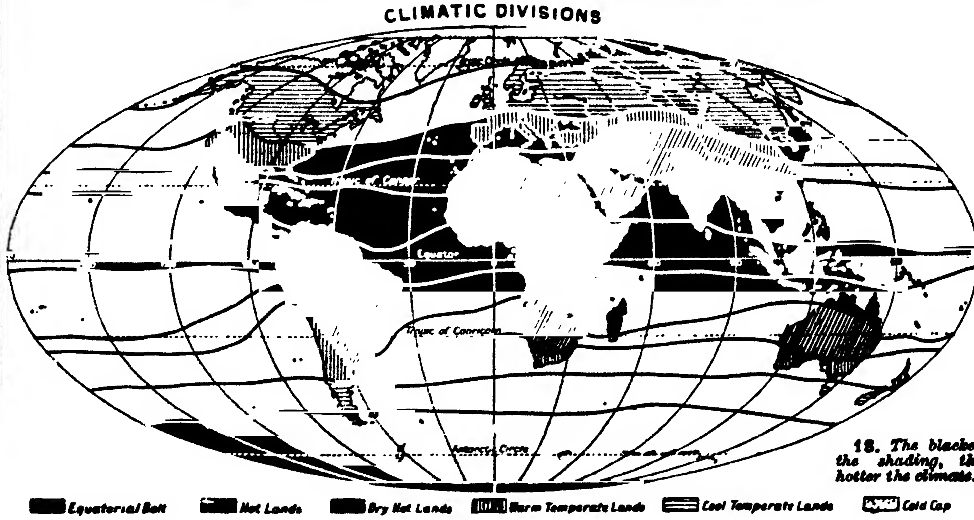


16. RAINFALL ALL OVER THE WORLD. The blacker the shading, the heavier the rainfall



17. *The shadings indicate the seasons of rainfall, not the quantity.*

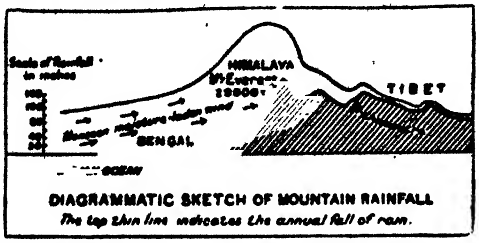
Scanty Rainfall — Summer Rains — Winter Rains — Rain at all Seasons



18. *The blacker the shading, the hotter the climate.*

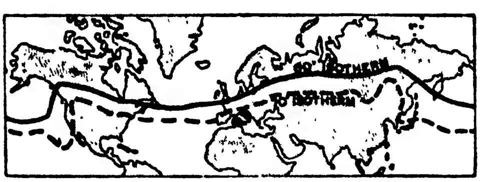
Equatorial Belt — Hot Lands — Dry Hot Lands — Warm Temperate Lands — Cool Temperate Lands — Cold Cap

when the southern hemisphere is similarly tilted. The air over this belt becomes extremely hot. When air is heated its particles expand and require more room, so that a given volume of hot air contains fewer particles than the same volume of colder air, and is consequently lighter. Being lighter, it tends to rise, forming what is called a low-pressure area. Over the heated equatorial regions the hot air is steadily rising, causing calms, which sailors call the doldrums. As it rises air is drawn in below. If the earth were at rest this indraught would be felt as north winds in the northern hemisphere, and as south winds in the southern hemisphere [14]. The earth, however, is rotating, and air flowing towards the equator is deflected to the right in the northern hemisphere and to the left in the southern. The indraught is, consequently, felt as north-easterly or easterly winds in the northern hemisphere, and as south-easterly or easterly winds in the southern.



19. The rainfall on the southern slopes of the Himalaya mountains is very heavy compared with the rainfall which falls on the northern slopes and in Tibet.

These winds blow throughout the year, blowing furthest north in the northern hemisphere in the northern summer, and furthest south in the southern hemisphere in the southern winter. As they can be counted on with certainty they are well called *trade winds*. Columbus owed his discovery of the New World to getting in their track. Meanwhile there is a corresponding movement of the upper layers of air, but in the opposite direction. The ascending air over the equatorial belt passes into regions of the upper air, where it is rapidly cooled. It cannot descend vertically because of the steady upward pressure of the rising air. It therefore streams outwards towards the poles, forming a return current. A proportion of this return current appears to descend almost vertically about lat. 30, forming a belt of high pressure in what are called the horse latitudes, where calms are consequently experienced. From this sub-tropical belt of higher pressure the surface winds flow out not merely as the trade winds towards the equator, but also on the other side towards the poles in temperate latitudes. Here deflection takes place as before—to the right in the northern hemisphere, to the left in the southern; and the outflowing winds consequently blow as south-westerly and westerly winds in the northern hemisphere, and as north-westerly or westerly winds in the southern. We are familiar with these westerly gales in autumn and winter, and they are still more strongly felt in the "roaring forties" of the southern hemisphere—the latitudes south of 40°—where sailors call them the "brave west winds."

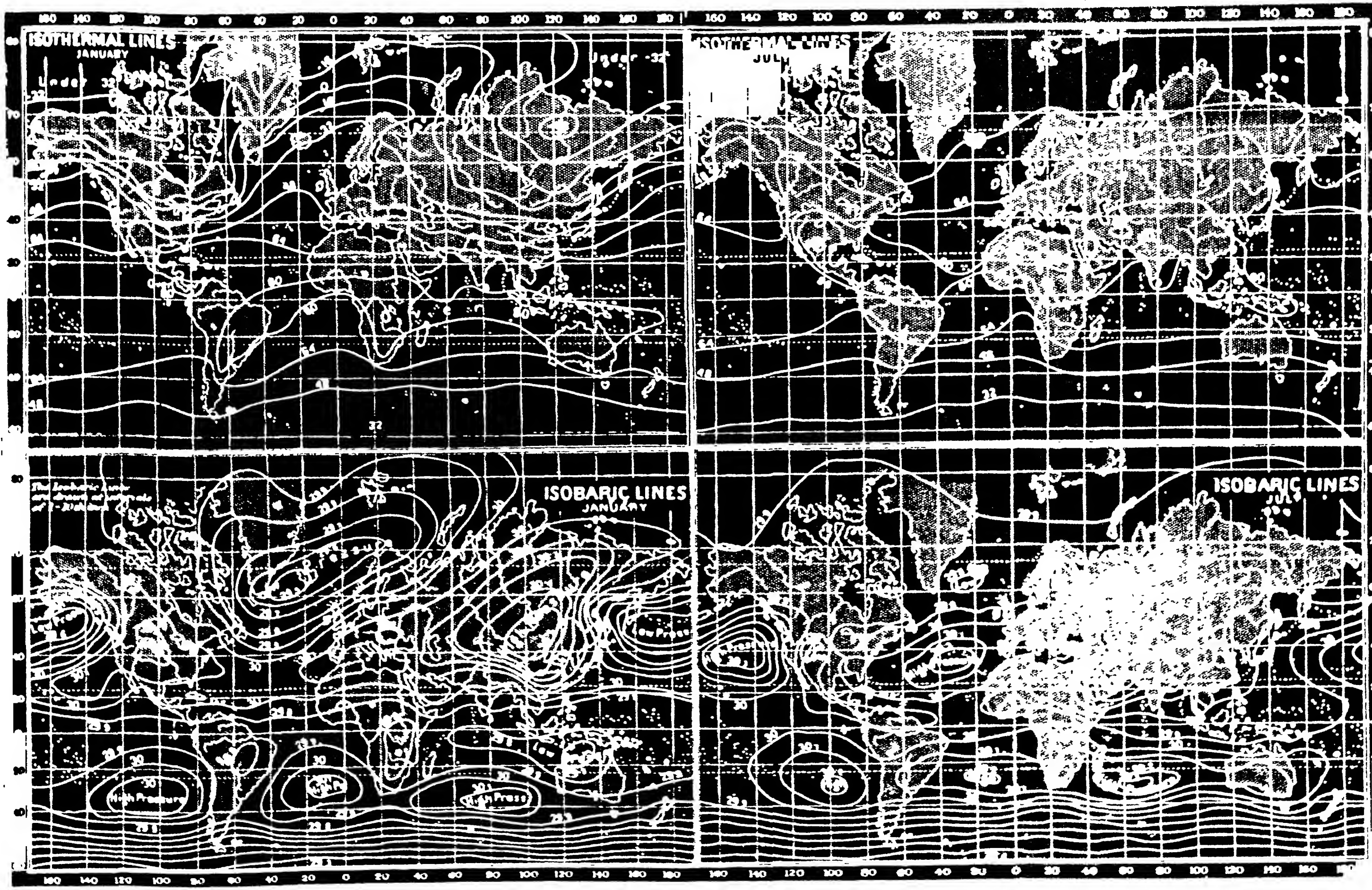


20. SUMMER ISOTHERMS OF 60° AND 70° FAHRENHEIT

The two lines are drawn through all places in the Northern Hemisphere having a mean summer temperature of 60° and 70° Fahrenheit.

Land and Sea Breezes. So far we have considered the wind system without regard to the distribution of sea and land. This, however, causes many local variations. Land, we saw, heats more rapidly by day and cools more rapidly by night than the sea. Consequently, along the margin of sea and land sea breezes tend to blow from the cooler sea by day, and land breezes from the cooler land by night. Exactly similar causes, acting over large areas of sea and land in intertropical regions, produce the seasonal winds known as *monsoons*, of which we hear so much in connection with our Indian possessions [15]. South Asia and North Australia lie north and south respectively of a broad belt of intertropical seas. During the summer the land becomes intensely heated, and the in-blowing winds from the sea acquire great strength. They are deflected to their right in the northern hemisphere, blowing over South-Eastern Asia as the south-west monsoon, and to their left in the southern, blowing over North Australia as the north-west monsoon. During the summer months they displace the north-east and south-east trade winds, which are sometimes called the north-east and south-east monsoons in these regions. Violent storms occur at the change of monsoon.

The Distribution of Rainfall. With few exceptions the heaviest rainfall takes place everywhere in summer, when evaporation is most intense, and the super-heated air is rising into the colder upper layers of the atmosphere. In intertropical regions, except in a belt on either side of the equator, rain falls only at that season, and the year is divided into a wet or summer season, and a dry or winter season. The rain belt moves with the equatorial heat belt, north of the equator in the northern summer, when the north tropical regions have their rainy season, and south of it in the southern summer, when the south tropical regions have their rainy season. Remember that the southern summer is the northern winter. As the equator is always in this hottest belt the equatorial regions have rain at all seasons, but most at the equinoxes. Hence the equatorial regions are sometimes said to



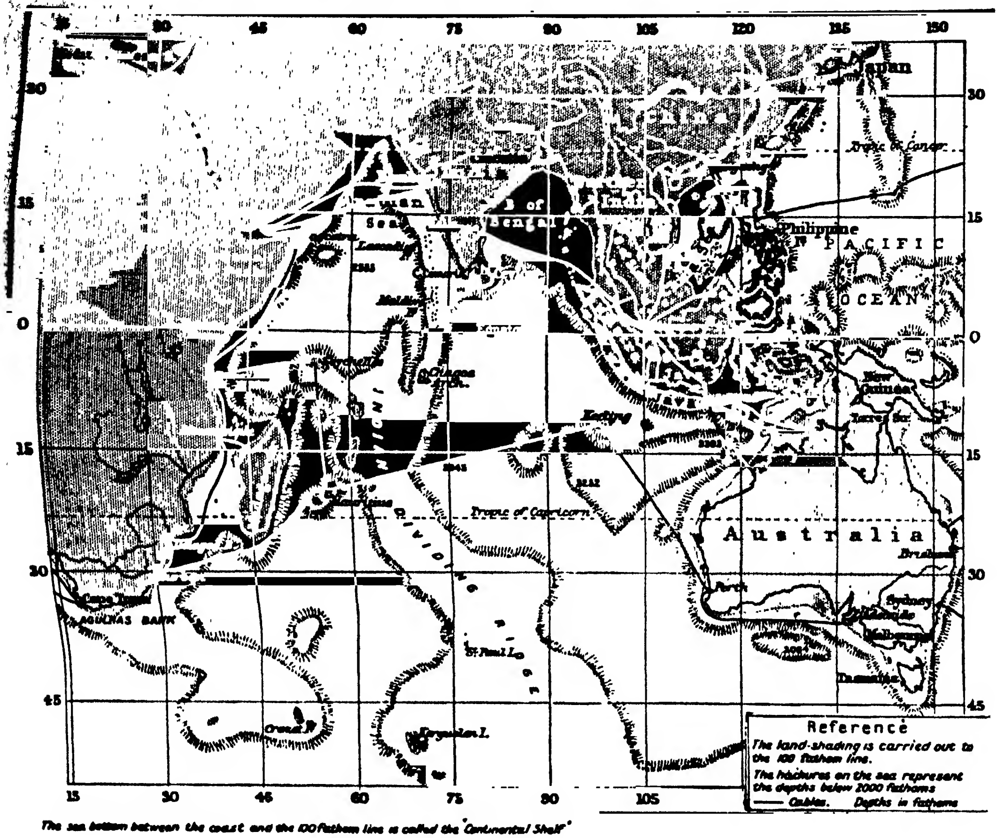
21. HEAT AND WIND PRESSURE: ISOTHERMS AND ISOBARS FOR JANUARY AND JULY

have two wet and two dry seasons. These terms are relative [17].

In the trade wind area there is little rain at any season, for the air is moving from colder to warmer regions, and cannot pick up moisture fast enough to become saturated. If, however, the trade winds strike against mountains which turn them upwards to colder regions of the atmosphere they may bring rain, though not profusely. In the monsoon regions the winds come oversea and are heavily laden with moisture, so that they are rain-bringing winds. The horse latitudes form a high pressure area, where air is descending from higher and colder to lower and warmer regions. Light variable winds prevail, or calms, and little rain falls. Consequently we find on either side of the equator a dry band in the lee of the trade winds, marked in both hemispheres by more or less extensive deserts. As the trade winds extend furthest towards the pole in each hemisphere in the summer of that hemisphere the dry belt in their lee also extends furthest towards the pole in that season, causing dry summers over limited areas. The dry summers of Southern Europe are caused in this way.

Beyond the horse latitudes come the regions where westerly winds blow all the year. They are oversea moisture-laden winds, bringing rain at all seasons. The heaviest rainfall is on the western coasts, especially where these are high. This belt of rainy winds moves nearest the equator in winter, bringing winter rains to the regions which were in the lee of the trade winds in summer. The winter rains of Southern Europe are caused by the southern extension of the westerly winds at that season.

While these are the broad lines on which rain is distributed there are many local variations, depending on various causes, of which the most

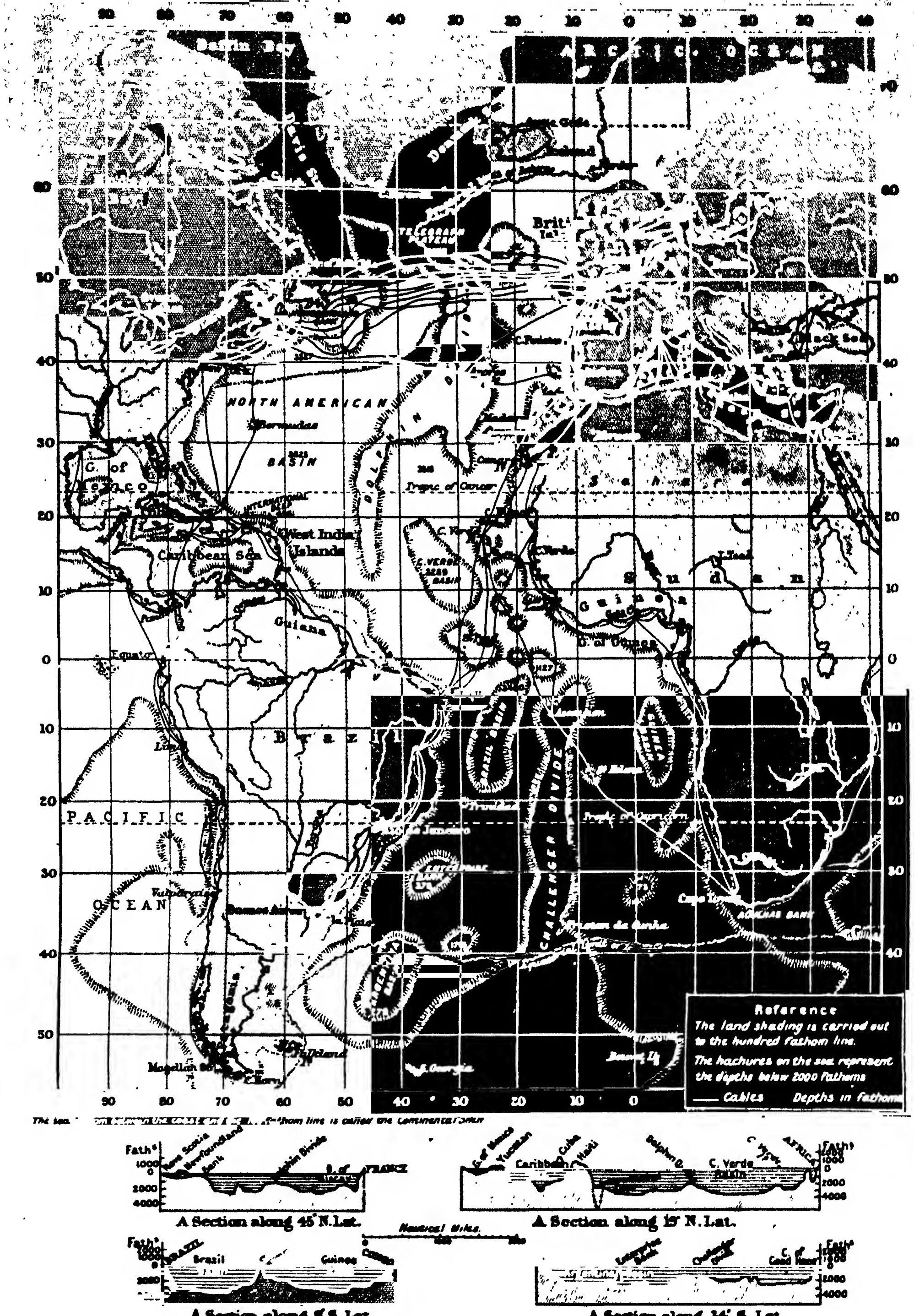


The sea bottom between the coast and the 100 fathom line is called the "Continental Shelf"

A Section along the Equator

A Section along 20° South Lat.

22. THE BED OF THE INDIAN OCEAN AND CHINA SEA, SHOWING THE CONTINENTAL SHELF



23. THE BED OF THE ATLANTIC OCEAN, SHOWING THE CONTINENTAL SHELF

important are the distribution of sea and land and of highlands and lowlands. The greater the distance from the sea, the less in general is the rainfall. Mountainous regions have always a higher rainfall than the surrounding lowlands, as they deflect the winds which strike them up into colder atmospheric layers. There is, however, usually a well-marked difference between the rainfall of their windward and leeward slopes, the latter being much drier. A mountain range lying in the track of winds laden with moisture may receive nearly all that moisture as rain or snow, leaving the winds to pass on as dry winds [19].

Climate. The first rough climatic distinction is into tropical, temperate, and polar climates, corresponding to the torrid, temperate, and frigid zones. This is too general to be of practical use. The causes so often referred to, the varying distribution of sea and land, and of high land and low land, produce many varieties of climate within a limited area. If a mountain situated on the equator is high enough, it will be crowned with perpetual snow, and though it has a tropical climate on its lower slopes, it will have a temperate climate above that, and a polar climate on its highest slopes. In making calculations it is usual to allow for a fall of 1° F. in temperature for a rise of 300 ft. in altitude. This figure is based on numerous observations made simultaneously at various heights on mountains in many parts of the world. The highlands, therefore, are everywhere colder than the lowlands in the same latitude. Look at any good relief map of the world, and you will see what a large proportion of the world has its climate affected in this way.

Equally important in its effect on climate is distance from the sea. We saw that sea-breezes cool the land in summer and warm it in winter—that is, they make the climate of neighbouring lands more uniform or equable. Where they are absent the summers are hotter and drier, and the winters colder and drier. In other words, the range of temperature experienced, varying from very hot in summer to very cold in winter, is great, and the climate is said to be extreme. The greater the land mass, or continent, the further is its interior from the sea, and the more extreme is its climate. Geographers call an extreme climate a continental climate, and one rendered equable by the influence of the sea, an insular or oceanic climate.

Climate, therefore, depends partly on latitude, partly on elevation, and partly on proximity to or distance from the sea.

Isotherms and Isohyets: Their Meaning and Uses. The result of all these causes taken together can only be ascertained by actual observation. For this purpose observation stations and self-recording instruments, which write out their own records, are at work all over the world. They have given us an enormous mass of information about the temperature and rainfall of most places on the earth's surface. The average of these for several consecutive years give us the average temperature or rainfall of any place. Maps are made showing the temperature and rainfall of different regions. A line is drawn on the map, passing, let us say, through all places where the average summer temperature is 60° F. Its shape will be very irregular, for it shows the result of several causes, which are acting in very varying degree. Another line may be drawn through all places with an average summer temperature of 70°. This line will also be very irregular for the same reason. Places with an average summer temperature between 60° and 70° will lie on neither line, but between the two, nearer one or the other, as the case may be [20]. Such lines are called *isotherms*, or *lines of equal heat*. They can be drawn for any temperature, and for any season, month, week, or day of the year required. They give an absolutely correct idea of the actual conditions of temperature produced at any place by all the causes at work, and enable us to compare different places in this respect [21].*

Similar lines, called *isohyets*, or *lines of equal wetness*, are drawn to show the rainfall, measured in inches, experienced by different places in a year, or at any given season. Places through which the isohyet of 40 inches passes receive 40 inches of rain in a year. Places through which the isohyet of 50 inches passes receive 50 inches of rain, and so on [16]. The maps which show how this is distributed in the various months are very important. There are many purposes for which we want to know if rain falls regularly through the year, or if one month is very wet and all the others very dry.

There is still another set of climatic maps, constructed to show the distribution of high and low pressure, which is indicated by *isobars*, or lines of equal pressure.

When we know the winter and summer temperatures of a place, the amount of rain it receives, and how this is distributed throughout the year, and the barometrical conditions, we know its climate, and can judge if it is fit for the home of man, and what sort of occupations can be carried on there with a reasonable chance of success. No atlas should be bought which does not contain maps showing the isotherms and isohyets, for these represent the data by which man has to be guided in his work in the world.

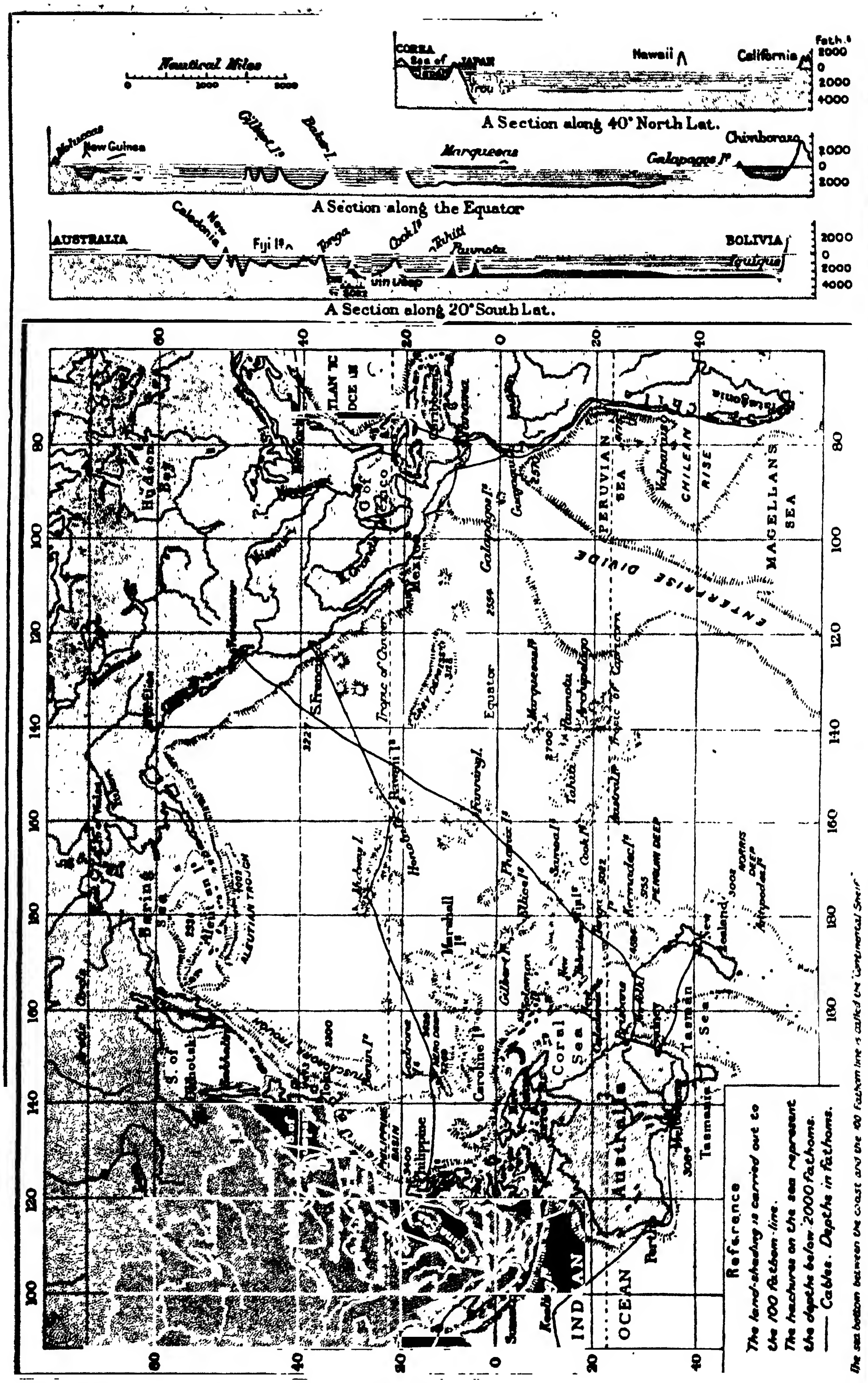
Climate Divisions. No hard-and-fast line can be drawn between climatic regions, for the transition from one to the other is extremely gradual. We may distinguish:

1. The equatorial regions, hot and wet at all seasons, with two wetter periods at the equinoxes.

2. The hot lands with a summer rainy season, including the monsoon lands in the trade wind area.

3. The hot dry lands, in the track of the trade

* Temperature observations are generally reduced to sea-level—that is, an observation has 1° F. added for every 300 ft. One of 48° F. at a station 1200 ft. high becomes 52° F. when reduced to sea-level.



24. THE BED OF THE PACIFIC OCEAN, SHOWING THE CONTINENTAL SHELF

POETRY: ITS ORIGIN, PURPOSE & VARIETIES

An Exposition of the Characteristics of Poetry, its Difference from Prose, and a Brief Guide to the Common Forms of English Verse

By J. A. HAMMERTON

IN a frankly utilitarian survey no one will look for anything so temerarious as an attempt to cover within the space of four pages a subject on which a whole library of learned works has been written. All that can be contemplated is the barest outline of some general principles with which we should be familiar before we set ourselves with any seriousness to the study of poetry.

Poetry is the first, as it is the highest, expression of the human mind. We may reasonably assume that there were poets long before alphabets; and when we hear anyone say "I cannot read poetry," we are to consider that person out of harmony with nature, as surely as the man who is deaf and dumb or blind, though he may never suspect his great infirmity. Of all forms of human expression, poetry is the most natural and direct; and it ought to be the readiest of response. Indeed, it is so. Despite all ignorant or flippant talk of poetry, the heart of a people always responds to it in moments of exaltation, and even those who confess they are unable to "read" poetry cannot escape its influence; since there is in the nature of mankind the stuff of poetry, which must at times manifest itself in all our lives.

What Poetry is. But what we really mean by poetry is not merely the ingenious arrangement of words and phrases in o lines beginning with capital letters and ending with words of similar sound; it is one of the elemental things of Nature, like electricity, and perhaps, in its deeper significance, no better understood. The Æolian harp may be taken as an illustration. This stringed instrument of the ancients, placed where the wind could blow upon it, gave forth sweet sounds. Man made the instrument, but Nature produced the music; neither acted alone —it was a relation of *inter*dependence. So with poetry: it is not merely Homer nor Dante, not Shakespeare nor Milton, who plays upon our feelings and our senses when we read his poems. He supplies the magic, emotion-fraught words, and we the listening hearts; but it is the soul of all remembered emotions and aspirations in each one of us—the very "rhythm of life," as one great critic calls it—that attunes these words to the needs and possibilities of each individual nature, and thus *applies* "poetry."

The Poetic Power of Words. The poet in this sense is the maker of the Æolian harp; Nature (as the winds and stirrings of our emotions) the player, and we the hearers, more or less acute, who catch or miss the sounds, according to our varying susceptibilities. Take the word "home" as an example. In no two minds does this monosyllable of four letters awaken *absolutely similar* ideas: "The old home," "home, sweet home," "home is home"— how colourless and inexpressive the word and these phrases are when coldly analysed; yet how they may each stir the pulses and quicken the memory when met with in poetry, and even in prose! And why? Simply because we associate our personal joys and sorrows with this index word and its connotations, and so become in a manner joint artificers with the poet. Hence the great poet is he who most successfully awakens in us, not only his, but *our own* thoughts and memories, by using the most expressive language in voicing his own thoughts and emotions. From this we shall rightly be held as esteeming emotional language essential to poetry. There is wonderful power in mere words. Tennyson all his life was affected by the words "Far, far away." As a boy they moved him poignantly. Who would ever have quoted Keats's famous verse:

"A thing of beauty is a joy for ever,"

if he had left it, as originally written, "a continual joy"?

The Beginning of Poetry. Although this helps us only a very little way towards the understanding of poetry, it does not seem too much to assert that by men first discovering the power to utter words potent to awaken responsive emotions in their fellows— having fitted first of all their own emotions, *of which the words were part and parcel*—began that intercommunion of souls which, in the course of ages, creating for itself certain conventions of form, shaped itself finally into what we know as poetry. In the earliest recorded history of our own land the bard had his place in the social scheme; and to a far greater degree than in our own time was the national need of poetical expression recognised, the poet articulating what his fellows felt but dimly and were quite unable to body forth. The bard was then, as now, both historian and prophet, interpreting his age to itself and to posterity.

These old Gaelic singers, in the early centuries of the Christian era, were often warriors as well; but many of them were more akin in their social status to the modern professional men of letters than any poets or historians in the intervening ages. The need of singers to arouse enthusiasm for battle, to celebrate victories, to mourn over defeats and commemorate the fallen heroes, was as great in those rude days of Fionn, Oisin, and Merlin as—to use a very homely illustration— the need of the political pamphleteer and leader-writer in modern electoral times; but many times more dignified, more in tune with Nature. Thus, in our own land, as twelve

hundred years earlier in Greece, when Homer celebrated the Trojan war in the first great poem of imperishable genius, the beginning of poetry as a literary expression was associated with "arms and the man"; but in the still more ancient "poetical books" of the Bible we have it associated with the divine aspirations of the soul; and the real beginning of English poetry was also religious, much of the poetic energy of our race, first expressed by Caedmon in the seventh century, being informed by a deep devotional spirit which has ever remained a characteristic of English poetry.

We must not at this stage be tempted further into the history of poetry, since in succeeding parts of our study we shall pursue the historical method by treating of poetry from Chaucer to our own time, and only those of us who are wishful to specialise in this branch of learning need turn our attention very seriously to the writings of William Langland, Laurence Minot, and the lesser poets who came between Caedmon (d. about 680) and Chaucer (b. about 1340, d. 1400).

The Criticism of Poetry. What will be of immediate practical use to us, indispensable indeed to the intelligent reading of any poetry, is a working knowledge of its constituents and varieties. This may be thought a wrong phrase to employ, smacking as it does of the laboratory; but while it is tolerably certain that the greatest of poets wrote almost unconscious of art, their exalted thoughts taking on an exalted and inevitable rhythm in perfect harmony with the canons of art, because *above* all art and of a piece with that elemental voice of Nature expressed in the well-known line from the Book of Job, "When the morning stars sang together"—because of this, we are open to believe that it is as possible to establish a scientific analysis as of any other energy of Nature. But it would be difficult to select a more controversial subject than the "scientific" criticism of poetry. This we may venture, however, to set down: that, as everything in life may be submitted to scientific analysis, there is no fatal reason why poetry should not also be subjected to such analysis. At any rate, none of the varying criteria whereby men have attempted to define and judge the poet's art has quite met the case, and the criticism of poetry is to-day about as difficult to define as poetry itself. For criticism has changed as persistently as art in standards of taste, else why in one age do we find artists denounced by their contemporaries who are acclaimed by posterity, and others admired by their contemporaries who are swept into oblivion by those who come after? To apply rigidly the standards of one age to the judgment of art produced in another is proved by certain historical examples to be futile. It is the glory of Aristotle's system of criticism that so much of it may still be applied to modern art; but criticism generally works out thus: after we have examined and accepted so many principles, the great new artist comes along and upsets our comfortable theories. In our own time Walt Whitman offers a good instance of this.

One thing that does seem to be within the range of even timorous assertion is, that rhythm and verse-form are the essential characteristics of poetry. Yet many eminent critics, Carlyle among them, have contended that prose can possess all the necessary qualities of poetry. It is generally agreed, however, that both poetry and prose have their "rhythm," while metre is the added quality of poetry, and this metre is not mere ornament, but of the very fabric of the thought itself. By which we mean that the emotions or thought-material of the poet whom we loosely call "inspired" have an inherent, rhythmic, metrical quality, which is not the mere literary decoration of the artist, but the very voice of Nature herself. Rhyme, on the other hand, is purely ornamental, and a non-essential of poetry, though so scholarly a critic as Dr. Johnson had a great distaste for blank verse, and an author of our own day, who enjoys considerable vogue, has had the fortitude to assert that a cat might be taught to write blank verse. This only illustrates how critics may differ, and must be our excuse for refusing, even if space permitted, to enlarge upon the controversial side of poetical criticism.

The Difference of Prose and Poetry. Let us, however, be bold enough to borrow from Mr. Mark H. Liddell's ingenious work, "An Introduction to the Study of Poetry" (with much of which we are unable fully to agree), what may be submitted as a rough working test of the fundamentals of poetry, before we proceed to note its metrical varieties. Mr. Liddell takes this passage from *Macbeth*, wherewith to test the qualities that render poetry distinct from prose:

> "Duncan is in his grave;
> After life's fitful fever he sleeps well;
> Treason has done his worst: nor steel, nor poison,
> Malice domestic, foreign levy, nothing,
> Can touch him further."

This we will presume to be poetry, despite the vapourings of Mr. Bernard Shaw as to his, or his cat's, ability—we are not quite sure which—to write like that. Mr. Liddell re-casts the passage in what may be called literary or rhythmic prose:

> "Duncan lies in his grave. Life, that racks my soul with succeeding ague-fits of fear, for him is over and he sleeps in peace beyond the reach of treason. The assassin's steel or poisoned cup, secretly fomented strife at home, treacherously assisted hostility from abroad—none of these can harm him now."

He next reduces it (though not quite successfully, we think) to "a bald statement of facts," as follows:

> "The life of Duncan is extinct, and he is no longer affected by the personal vicissitudes and dangers of government, such as assassination, treason, rebellion, and foreign invasion, which produce this anxiety in my mind."

Mr. Liddell then proceeds to examine these three forms of the same thought. The last (which, for this experiment, may be regarded as the first form of the thought) is, he considers, so plain and dispassionate a statement of the fact that it would hardly awaken any strong emotions in the breast of anyone save Macbeth himself. It is *not poetry*. But the second is framed in words charged with emotional qualities, which must necessarily affect the feelings of all readers, though not invariably touching them to the same issues. This added quality in the second stage we are to denote as "Human Interest," and this Mr. Liddell very rightly considers the determining element of literature: "that common and general interest, which its thought possesses for all men who think, regardless of those peculiar attitudes toward life that arise from peculiar pursuits and occupations"—a doctor, for instance, not looking on death in the same way as a non-medical man or woman, nor an undertaker finding in the word "grave" the same emotions as one to whom the surroundings of the tomb are less familiar. Still, the second stage is *not* recognisable as a *poetic form*.

Matter and Form. But, in the third stage (or, properly, the first Shakespearian form), the thought material is, both in substance and in form, in warp and woof, as it were, poetical; or at least what only a mountebank critic or a blockhead would refuse to regard as poetry. This may be explained on several grounds, but the change is due chiefly to the regular rhythm and the metrical movement of the verse, which punctuate the thought; marking off its different "impulses," its "units," and projecting vividly into the mind of the reader what was in the mind of Macbeth; not—let us note—merely what was in the mind of Shakespeare; for this is an instance of what Mr. Theodore Watts-Dunton calls "absolute vision," the vision of dramatic poetry. The thought and expression here seem to us *one and indivisible*, which may prove even more than Mr. Liddell set out to prove: that in the two forms into which he altered the passage, he must have taken away more than expression, so that his "bald statement" of the fact was really not a statement of the fact at all, the *real full fact* existing only first and last in the thought *and* form of Shakespeare's verses. We might advance our point by giving a simple illustration. Edgar Allan Poe wrote two of the finest lines in poetry:

> "To the glory that was Greece,
> And the grandeur that was Rome."

But he had written them previously thus:

> "To the beauty of fair Greece,
> And the grandeur of old Rome."

In changing the words, he not only charged the lines with a grander music, but vitally altered, expanded and improved the thought.

But this is a point that need not detain us. Enough that we have got, roughly at least, a hint of the difference between literary prose and poetry; and we fear to venture further along "scientific" lines, remembering Stevenson's unhappy example in that direction.

The Dividing Line in Poetry. There is one great dividing line in poetry itself which must be understood at the beginning, and this is nowhere so clearly defined as by Mr. Watts-Dunton in his famous article on "Poetry" in the "Encyclopædia Britannica" (which no student of literature should omit to read). He there says that "of poetic imagination there are two distinct kinds: (1) the kind of poetic imagination seen at its highest in Æschylus, Sophocles, Shakespeare, and Homer; and (2) the kind of poetic imagination seen at its highest in Pindar, Dante, and Milton, or else in Sappho, Heine, and Shelley. The former, being in its highest dramatic exercise unconditioned by the personal or lyrical influence of the poet, might perhaps be called absolute dramatic vision; the latter, being more or less conditioned by the personal or lyrical impulse of the poet, might be called relative dramatic vision." Let us bear this in mind, as it will greatly help us to appreciate poetical values.

Rhythm. By this term is meant the *regular recurrence* of certain fixed sound-relations determined by time and stress, or by quantity and accent. Attempts have been made to establish the measurement of English verse on the principle of syllables and pauses, as with French poetry; and this, though unsuccessful as a whole system, has modified the classical rhythm of long and short syllables to the modern rhythm of accented and unaccented syllables. Neither is a perfect measure applied to English verse, but we must work with the latter as best we may, using terms of classical prosody not quite suited to English poetry. When rhythm is measured by "feet," it becomes metre.

Metre. This is the definite measurement of poetry by feet and verse of different lengths, a verse or line containing several feet. Thus we have monometer, dimeter, trimeter, pentameter, hexameter, etc., or, in simpler language, verses of one, two, three, four, five, and six feet.

Feet. There are in English poetry—to which we must confine ourselves in the present study—four principle feet, known as the anapæst, the dactyl, the iambus, and the trochee. The *Anapæstic* foot consists of two short or unaccented syllables, and one long or accented syllable thus:

> "Thĕ Ăssy̆r|ĭan cāme dōwn | lĭke ă wōlf | ŏn thĕ fōld,
> Ănd hĭs cō|hōrts wĕre glēam|ĭng wĭth pūr|plĕ ănd gōld."

There are four feet in each of these verses, which are thus known as anapæstic tetrameters. The *Dactyl* is the reverse of the anapæst, consisting of one long and two short syllables:

> "Cōme tŏ mĕ, | dēarĕst, Ĭ'm | lōnely̆ wĭth | *out thee.*"

The final foot of this verse, which consists of the two syllables we have italicised, is not a dactyl, but a spondee, or a foot of two equal

accents, with which a dactylic verse usually ends. The *Iambus* is by far the most common feature of English poetry, and is the measure of our heroic verse. It is an unaccented syllable followed by an accented one, as:

"Uneăsily̆ liēs | thĕ hēad | thăt wēars | ă crōwn."

Lines of five such feet, if they rhyme with others, are known as "heroic verse"; and if unrhymed they form "blank verse." It is in this blank verse that the plays of Shakespeare and the poems of Milton are written. The *Trochee*, so far as English poetry is concerned, is, practically speaking, the opposite of the *iambus*, being a foot in which an accented syllable precedes an unaccented one:

"Līves ŏf | grēat mĕn | āll rĕ | mīnd ŭs," etc.

The term is also used in connection with the pause or cæsura, a trochaic cæsura being a pause between the two short accents of the dactyl in the second, third or fourth foot of the hexameter; thus there would be a trochaic cæsura after "dearest" in the line,

"Come to me, dearest | I'm lonely without thee,"

the pause indicating a new thought-impulse.

Rhyme. This is a totally different thing from "rhythm," and is quite unnecessary to poetry. It is, we have heard, only an ornament, but for that reason is identified with certain kinds of verse whose æsthetic beauty lies largely in their form. It is chiefly associated with lyric poetry, or the poetry of personal emotion, which comes under the classification of "relative vision." The *sonnet*, the *elegy*, the *ode*, the *psalm*, and the *hymn* are all included in lyric poetry. The meaning of the word "rhyme" is so apparent that it need not be illustrated, but beginners should know that wherever a poet ends a verse with a rhyme-word in which the accent falls on the second last syllable, there must be an extra syllable in that line, and in its companion. Thus, in stanzas of iambic pentameters it is often necessary to introduce lines in which eleven syllables occur. But in blank verse only the one line ending with a word accentuated on the penultimate syllable requires the extra syllable. Thus Shakespeare writes:

"Tell him this tale; and from the mouth of England
Add thus much more,—That no Italian priest," etc.,—

the one line of eleven and the other of ten syllables. While Dryden, in his satire "Absalom and Achitophel," which is composed in the heroic couplet, writes:

"Praising and railing were his usual themes,
And both, to show his judgment, in extremes.
So over violent, or so over civil,
That every man with him was god or devil."

The first couplet has ten and the second eleven syllables in each line, as the accent falls on *civ*-il and *dev*-il. (It will also be noted that the poet meant "violent" to be a word of two syllables only.) Such double rhymes are called also "feminine rhymes," and there is the "feminine cæsura," or pause between two unaccented syllables:

"I stood in Venice | on the Bridge of Sighs."

A masculine cæsura is a pause occurring between two accented syllables. The pause is usually required near the middle of a verse, but varies according to the incidence of stress and accent. The only further remark that may be made in respect to rhyme is that when the ear is conscious of some unnatural or fantastic rhyme, a false or strained accent in the verse, the poet has failed, as the form should not interfere with the even flow of the thought: the manner should not distract our attention from the matter. In poets of the past allowance has to be made for the constantly changing fashions of accentuation.

Space does not allow of our entering further into detailed explanation of the varieties of poetic form, which, as we proceed with our studies, will have to be examined; but we may now claim, even if we have soporised somewhat with the "scientific" criticism of verse and with modern prosody, to possess some knowledge which we can immediately apply in our reading of poetry.

EXERCISE IN ENGLISH METRE

Define the varieties of verse illustrated in the following quotations, and mark each accor… 'y:

1.

For the earth he drew a straight line,
For the sky a bow above it,
White the space between for daytime,
Filled with little stars for night-time.

2.

This royal throne of kings, this scepter'd isle,
This earth of majesty, this seat of Mars,
This other Eden, demi-paradise;
. . . . .
This blessed plot, this earth, this realm, this England.

3.

Man is a ship that sails with adverse winds,
And has no haven till he land at death.

4.

Henry, too, hath here his part:
At the gentle Seymour's side,
With his best-beloved bride,
Cold and quiet here are laid
The ashes of that fiery heart.

5.

State what is wrong with this line from Milton:

"Void of all succour and needful comfort."

6.

Farewell to others, but never we part,
Heir to my royalty, son of my heart.
Bright is the diadem, boundless the sway,
Or kingly the death that awaits us to-day.

7.

Like the leaves of the forest when summer is green,
That host with their banners at sunset were seen:
Like the leaves of the forest when autumn hath blown,
That host on the morrow lay wither'd and strown.

To be continued

Group 4

BUILDING

2

FIRST ESSENTIALS IN BUILDING OPERATIONS

A Consideration of the Leading Operations incidental to the Beginning of any Building Undertaking

By Professor ELSEY SMITH

THE various operations incidental to the working up materials into complete structures are varied and complicated. In the simplest building workmen belonging to two or three different trades are employed, and in most buildings the majority of trades are represented. Separate sets of workmen are employed, as a rule, in each of the different trades. They are roughly divided into unskilled workmen or labourers and skilled workmen, those who have received a training or apprenticeship in some craft requiring manual dexterity. The unions regulating the different trades lay down rules limiting the class of work that the tradesman in each trade may perform, and a skilled artisan may not, as a rule, perform labourer's duties.

The Workmen. The labourer performs most of the heavy work of building operations, such as unloading materials and supplying them to the skilled workmen, and are told off for this purpose. They also execute excavating and concreting. Superior labourers are specially employed as drain layers and for erecting and altering scaffolds. The latter are termed scaffolders.

The tradesmen who are skilled artisans comprise the bricklayer, who also sets terra-cotta work and faience; the pavior, including mosaic worker; the mason, including the slate and marble mason; the carpenter; the founder and smith, including the structural iron and steel worker; the gasfitter; the slater or tiler; the external plumber; and the zinc worker and coppersmith. In some of these trades, which are employed in erecting and covering in the actual structural work or "carcase" of a building, part of the work may be prepared elsewhere; but in each a great part of the work is necessarily executed on the spot. The other principal trades are those of the plasterer; the joiner, who usually also supplies and fixes the ironmongery; the electrician for lighting, bells, and sometimes power; the internal plumber, who provides hot and cold water supply, and various sanitary fittings; the painter and decorator; the glazier and the paperhanger; the services of the heating and ventilating engineer, and of the electrician, are also often included. In the case of the joiner, the work is mostly prepared at the builder's yard and brought to the building practically ready for fixing, but the work in other finishing trades is largely carried out on the spot. Fireproof work, heating and ventilation, though special work, is usually carried out by one or more of the above tradesmen under special supervision.

The Foreman. A *General Foreman* is appointed by the builder, and his duties are numerous; not the least important is that of organising the work of the different tradesmen so that they may follow each other without interruption and, if possible, without reducing, even temporarily, the number of men employed. He is also responsible for the ordering of materials from the builder's yard, and for the quality of the work. He makes to the builder a return of the money earned weekly by each workman, and of all work executed, materials used and required, and of time and material expended on day work as distinct from contract work. In a large business there is often a walking foreman, who visits and generally supervises all works in progress. On a large building each of the important trades has also a foreman whose duties are less wide, being confined to the work in his particular trade.

The *Clerk of Works*, when one is employed, is appointed by the architect as his representative on the building during its erection, and it is his duty to examine all materials, to satisfy himself that they are as specified, to oversee the work generally, to see that it is sound, well put together, and executed in accordance with the drawings and specification. He should render a weekly report to the architect, detailing the state of the work, the materials received, the drawings received and required, the number of workmen in each trade, and the state of the weather.

Drawings. Before the erection of any building a set of drawings, generally to a scale of ⅛ inch or ¼ inch to the foot, and showing the work to be executed, is prepared. The drawings should show plans of every floor or story, of the foundations and roof, and of the site and drainage: elevations of every side of the building, and two or more sectional plans of different parts of the building, the number depending on its size and complication.

These are the *General Drawings*, and are supplied to the builder by the architect; they are drawn to scale and should indicate, in as much detail as possible, all the work to be executed as far as it can be foreseen. They form the most important source of information that the builder has regarding the disposition of the building. Copies of all of them, or of the most important, are submitted to the local authorities before work is begun. This is required so that the surveyor to the local body may ascertain that the work is designed in accordance with any bye-laws or regulations affecting the conditions of building in the particular district. Both the foreman and clerk of works should have a complete set of general drawings on the works in addition to the set given to the builder.

Specification. The builder is also furnished by the architect with a written description of the work to be executed. This is termed

work at once, but there may possibly be trees to fell or shrubs to remove. Where the site has been previously built upon, existing buildings must be removed; if they are small, this may be left to the builder, who pulls them down and removes the materials, excepting any permitted to be re-used, giving a credit for them; but in the case of large buildings a *Housebreaker* is called in to take down the old buildings and remove the materials before possession of the site is given. In the case of alteration to existing buildings the old work may have to be temporarily shored, and this work will be dealt with later in the Course. Temporary screens or partitions may also be found necessary, if the old building is to be used for residential or business purposes during the alterations, or if the builder is not to have complete possession of it. Such screens are lightly framed, covered with boarding or canvas and papered to keep dust from entering; if they are required to keep out weather a tarpaulin should be placed over the screen when it is fixed.

When an alteration involves the removal of an existing roof temporarily, a frame is formed above it with scaffold poles and boards laid at short intervals and the whole is covered with tarpaulins, which should be arranged with a slight fall in one direction to throw off any water, and be at such a height as to allow of the required work—it may be the addition of a story to the building—being carried out under it.

Setting Out. The plan of the building must be carefully set out upon the ground; the ground plan should be fully dimensioned for this purpose. If dimensions are not figured they must be taken off with a scale. In town sites the exact position is usually fixed by contiguous buildings, but on an open site the position may only be finally settled after more than one trial, so that the best aspect and point of view may be secured. With large and complicated buildings the setting out, especially if the plan is irregular, may be a somewhat difficult process, and may be facilitated by the use of a theodolite [See SURVEYING], for fixing the main lines and angles.

The builder is required to set out the building, and may be held liable for mistakes, and accuracy is very essential; it is of great importance to see that all right angles are truly square and all other angles correctly set out. When the outline is fixed the thickness of the main walls and the projection of the footings and concrete require to be marked. This is usually done with boards fixed horizontally to two stakes driven into the ground in line with the wall to be defined and placed so far beyond its ends as not to be interfered with by the excavation of the site. On each board cuts are made on the upper edge marking the inner and outer face of the wall and the footings, and concrete on each side may be marked with similar cuts or by nails. A line, strained between the two boards, will allow of a plummet being dropped at any point along the line of the wall or its foundations, whereby its exact position may be fixed.

Levels. It is further necessary to fix the level of the ground floor, or of some other well-defined level in the building; this also should be marked on some adjacent object that will not be interfered with, and from which a horizontal line can be levelled across to the site by means of a dumpy level [See SURVEYING], or by a series of stakes the tops of which are accurately levelled with a straight-edge and carpenter's level.

From the fixed level, termed a datum, measurements can be taken defining the depth of the foundations and the heights of various parts of the building, where they are not uniform; long rods, called *story rods*, are set out on which the level of the upper floors, windows and other features are marked and by which the accuracy of the work as it proceeds can be checked. The datum level should be shown upon the drawings and all levels given in relation to it; the most convenient datum, as a rule, is the level of the principal floor above the ground at the entrance, or some real or imaginary line above or below it. When a fixed point on the ordnance survey is near a building, it may be very conveniently taken as a datum, and the level of the principal floor fixed in relation to it.

Additions and Alterations. Changes are frequently required in existing buildings, and are in many cases somewhat troublesome. Difficulties in levels and planning have often to be overcome so as to provide an addition that shall, when completed, form an integral working part of the original structure without awkward features or changes of level in the floors.

It frequently happens that the work of alteration is more troublesome to the builder than would be the erection of an entirely new structure, and the circumstances affecting the execution of the work require very careful consideration in arriving at an estimate of price. Any difficulties should be referred to in the specification where one is provided. A few of those that frequently arise in such cases may be discussed. The special provision of screens and protection has been already mentioned. These are easily provided for, but the effect of some working conditions can only be estimated with a very wide margin for accuracy. One of the most important limitations is often that of working space for storing materials, sheds, &c., the result being that materials must be delivered in small quantities and at short intervals, requiring much foresight on the foreman's part. Another very serious factor with some alterations is the necessity that the occupier should keep the business in full swing during alterations. In the case of a shop—*e.g.*, protection for the goods and access for the public may have to be maintained, or, in the case of a factory or works, communication between different parts may be necessary notwithstanding that the building operations may come between them. Also there is often increased expense in executing new work to correspond with existing work; this is especially the case in matching the colour of brickwork and in dealing with the details of finishings.

A SHORT DICTIONARY OF BUILDING CONSTRUCTION

Terms peculiar to individual trades are dealt with in their respective departments.

ABUTMENT—The solid part of a pier from which an arch springs directly.

Ancient light—An opening for the admission of light and air that has, by prescription, obtained a legal right to such easement in perpetuity.

Angle of repose—The natural angle at which any given material will remain at rest.

Annulet—A fillet or band circular on plan.

Applied ornament—Ornament attached to the surface, not worked on the solid.

Area—An enclosed court or yard. A sunk space arranged for lighting or for access to a floor below the ground level.

Arris—The line formed at an exterior angle by two intersecting surfaces.

Aspect—The quarter of the heavens which any front or opening of a building faces.

Astragal—A small moulding semicircular in profile.

Attend upon—A term indicating the assistance to be given to each tradesman by other trades.

Attic story—A story formed wholly or partly in a roof.

BALCONETTE—A small balcony.

Barrel roof—A roof of which the soffit is semi-cylindrical.

Base—The foot or lowest portion of any part of a building.

Basement—The story of a building below the principal or ground floor.

Bay—The subdivision longitudinally of a building by piers, arches, girders, etc.

Beam—A piece of timber or iron placed horizontally—generally over a void.

Beam compass—An instrument for drawing large circles composed of a lath and adjustable slides carrying the point and pen and pencil.

Bearing—The area of support to the end of a joist or beam. Also used to denote the clear distance intervening between such points.

Bed—The horizontal surface on which stones, bricks, and other substances used in building rest. In arches the bearing surface on each side of a voussoir.

Bed mould—A moulding immediately below and apparently supporting an overhanging surface.

Bevel—The slope formed by cutting off a right-angled arris by a plane intersecting both original planes.

Block plan—A plan showing a site on which only the outline of buildings is indicated.

Boning—The act of making or judging a plane surface or line by the eye.

Break—The recess or projection of one piece of work behind or in front of the remainder.

Bullnose—A rounded junction between two surfaces enclosing an angle.

Buttress—A mass of masonry or brickwork so disposed as to counteract the thrust exerted by an arch or vault.

CAMBER—A slight convexity to counteract deflection due to load.

Camp-sheeting—A timber retaining-wall to prevent erosion in rivers and canals.

Cant—Any part of a structure formed at an angle other than a right angle.

Cantilever—A beam, bearer, or girder, one end of which is free and the other fixed.

Cap—The crowning member of a pier or column.

Capping—A moulding or group of mouldings on the top of a dado, screen, or gate.

Carcase—The structure of a building before finishings are added.

Castellated—Terminated with battlements.

Catch-pit—A pit formed to collect fluid or solid matter.

Caulking—The stopping of open joints.

Chamfer—See Bevel.

Channel—A long sinking formed in the ground or on the surface of any material.

Chisel-pointed—With a flat, broad point.

Cinquefoil—A form of enrichment having five cusps.

Circle on Circle Work—Work circular in elevation as well as on plan.

Clearstory or **Clerestorey**—A range of windows placed high up in a hall or church.

Clear, In the—The net distance between any two points or surfaces.

Clear span—See **Bearing**.

Clerk of Works—An individual appointed to superintend building operations on behalf of the architect.

Coffer—A sunk panel in a ceiling or soffit.

Coin or **Quoin**—The external angle formed by the junction of two walls.

Collar—A ring of metal or other material placed round any object.

Colonnade—A range of columns.

Column—A vertical circular support.

Concavity—The hollow side of a curved line or other object.

Concentric—Circular figures or portions of circles struck from a common centre.

Conduit—A term applied to a channel or pipe used for the conveyance of fluids.

Console—An ornamental bracket used to give real or apparent support to a cornice or other feature.

Convex—The swelling side of a curved line or other object.

Contrary flexure—A curve, part of which is convex and part concave.

Corbel—A projection from a wall to carry any overhanging portion.

Core—The interior, heart, or centre of any object.

Cornice—A group of mouldings crowning a wall or other surface.

Corona—A broad vertical face in a cornice with an overhanging soffit.

Countersinking—A sinking formed in timber or other material to receive the head of a screw or bolt that it may be flush with or below the surface.

Cove—A large hollow moulding generally formed in the cornice of a ceiling.

Crank—A rigid arm fixed at the end of a shaft perpendicular to its axis.

Cresting—An ornamental finishing to a ridge or parapet.

Crib—A stable rack.

Crown—The highest part of an arch or vault.

Crushing Load—The load under which any material loses its power of cohesion.

Culvert—A circular underground channel for conveying fluid.

Cupola—A spherical roof or dome.

Cusps—The points between the foils of a foliated arch.

DADO—The central feature of the pedestal of a column, or a deep band, usually with base and capping at the base of a wall.

Dead load—A permanent load, one which does not move.

Dead shore—A vertical timber strut receiving a dead load only.

Dentils—Square blocks carved out of a projecting fillet.

Detrusion—An outward thrust tending to separate one body from another. A shearing strain acting parallel to the fibres of a material.

Die—Another term for dado. Also a mould from which objects in relief may be struck.

Dome—A convex roof over a circular or polygonal building.

Dominant tenement—In the case of an easement the tenement to which the privilege belongs.

Dormer—A window placed on the inclined plane of a roof the front of which is vertical.

Dressings—Brickwork, terra-cotta or masonry finishings of a superior quality introduced into rougher walling.

Drum—A vertical, circular, or polygonal wall carrying a cupola or the blocks of material composing the shaft of a column.

EAVES—The lowest edges of the inclined sides of a roof projecting beyond the walls.

Elastic limit of any material—The greatest strain that does not produce a permanent set.

Elevation—A geometrical projection representing the outer surface of an object on a perpendicular plane.

Embossing—The raising or forming of any form or design above the surrounding surface.

Engraving—The cutting in or sinking of any form or design below the surrounding surface.

Enriched mouldings are those whose profile is treated with ornament.

Entering angle—The internal angle formed by the intersection of adjacent surfaces.

Entresol—A room formed above another in the general height of a lofty story.

Estimate—The computed cost of any work.

FABRIC—A term applied to the structural portions of buildings.

Façade—The face or front of any building.

False bearing—A column or wall bearing on the unsupported part of a girder.

Fan—An apparatus for mechanically changing or moving air. A hoarding projecting outwards during pulling down.

Fatigue of material—The failure of material under a recurring load which produces a stress exceeding its elastic limit.

Feather edge—A term applied to any thin body having one edge thicker than the other.

Fillet—A narrow flat band.

Finial—The ornamental finishing of a pinnacle, gable, or turret.

Finishings—The various works to complete a building after the shell has been erected.

First floor—The story next above the ground floor, so also with second floor, third floor, etc.

Fixture—An article of a personal nature affixed to land or buildings, whether movable or not.

Flange—A plate projecting from the side or end of a piece of wrought or cast metal.

Flank—The return or side part of a body which joins the front and rear.

Flush—A term signifying the continuity of surface of two bodies joined together.

Flutes—Channels on a vertical shaft.

Foil—The small arcs used in tracery to enrich a larger curve.

Foliated—The use of foils in tracery.

Foundation—The basis, natural or artificial, upon which a superstructure is raised.

Frieze—A broad band, ornamental or otherwise, immediately below a cornice.

GABLE—The vertical triangular end of a sloping roof.
Gablet—A similar feature used as an ornament in buttresses.
Gangway—An open passage-way, temporary or fixed.
Girder—A beam used to support a load over a void.
Girt or Girth—The length of the circumference or profile of an object.
Gradient—The vertical rise in a path or road compared with its length.
Grille—An enclosure formed of crossed bars.
Ground plan—The plan of a building taken at the ground floor level.
Guides—Groov s in which a sliding door or shutter runs.

HALF-LANDING — An intermediate landing in a staircase, extending right across the well-hole.
Half-timber—A structure framed of large timbers, the panels filled in with brick or plaster.
Head-room—The space above a flight of stairs necessary to allow free passage.
Herring-bone work—Blocks of material laid diagonally, the end of each butting against the side of the next block.
Hipped-roof—One in which adjacent sides are inclined and form salient angles.
Hood—A projection to protect an object beneath it from the action of the weather.
Housebreaker—A contractor who pulls down existing buildings and clears away the materials.

IMPOST—The capping of a pier or pilaster that receives an arch.
Incrustation—Material, usually decorative, applied by some connecting medium to another body; or a deposit caused by chemical decomposition.
Inlaid work—Work of which the surface is partly cut away and filled in with other materials.
Intaglio—Ornament sunk below the general surface of a piece of work.
Inverted arch—An arch formed below instead of above its springing line.

JACK—A machine used in building operations to move heavy loads.
Jamb—The vertical sides of an opening in a wall.

KILN—A structure in which materials are calcined or burnt.

LABEL—A projecting drip moulding around an aperture.
Landing—The floor terminating a flight of stairs.
Lateral thrust—The outward force exerted by an arched or framed structure.
Lattice—Open work made by crossing strips of iron or wood.
Level—An instrument used by the carpenter and mason to indicate when a line or surface is parallel with the horizon. (See also **Surveying.**)
Live load—A load consisting of bodies subject to motion.
Loose box—An enclosure within a stable in which a horse can be left loose.

MALLEABLE—Material susceptible of extension under the blows of a hammer.
Market sizes—The sizes in which timber and other materials are stocked and sold.
Mezzanine—A story of small height between two higher ones.
Mitre—A plain joint between two similar pieces of material or mouldings bisecting the angle at which they meet.
Mosaic—An incrustation formed with small cubes of marble, stone, glass, etc.
Moulds—Patterns or contours from which work is wrought. A prepared case into which certain fluid materials are introduced to set or cool, or in which plastic materials are given definite forms.
Mouldings—The ornamental contours given to the projecting or receding edges of materials.

NECKING—Any small moulding near the top of a column or pilaster.
Neutral axis—The plane in a beam at which the stresses change, the effect of the stresses being nothing.

ORIEL—A window similar to a bay corbelled out on an upper story.
Out of winding—Material the surface of which is true and free from twist.
Out to out—A dimension taken to the extreme limits of any body or material.

PANEL—A surface enclosed by a frame and sunk below it; an imitation of such a feature in solid material.
Party wall—A wall used for separating adjoining buildings belonging to different owners.
Party fence wall—A wall standing on lands of adjoining owners as a separation of adjoining lands.
Pedestal—A short pier with base and capping under a column or statue.
Pendant—An ornament suspended below the main part of a structure.
Pendentive—The triangular portion of a truncated hemisphere formed by cutting it with two vertical planes each making an angle of 45° on plan with the end of its lower diameter.
Penstock—A small paddle working in a grooved frame for penning back water.
Penthouse—A shed having a lean-to roof.
Permanent set—A permanent change of form produced in an object due to straining the material beyond its elastic limit.
Piecework—Work paid for by the piece or job—not by time.
Plan—The representation to scale of any horizontal section of an object.
Plinth—A square projecting member at the base of a wall or below a moulded base.
Plotting—The process of laying down on paper to scale the plan, elevation, and section from measurements of an existing building or piece of land.
Plumb—Vertical.
Profile—The actual outline of any moulding or other body as shown by a plane drawn perpendicular to its surface.

QUADRANGLE—A square or rectangular court, generally within a building.
Quarter space landing—A landing in the angle between two flights of stairs making a right angle.

RACKING—The tendency to distort a piece of framing diagonally.
Raking—A member inclined at an angle with the horizontal.
Rampant arch—One whose abutments or springings are at different levels.
Re-entering angle—An angle the plan of which is sunk or returned as opposed to a solid angle.
Relievo or relief—Ornament raised above the surface of a piece of work.
Respond—The abutment of the last arch of an arcade.
Return—The continuation of a surface or moulding round an angle.

SAFE load—The permanent load any material or structure will safely support.
Salient angle—The external angle formed by the intersection of adjacent surfaces.
Scale—A line bearing some definite relation to the full size of an object and subdivided for the purpose of plotting.
Scantling—The dimensions of breadth and thickness in a piece of timber; and of length, breadth and thickness of a stone.
Seating—A carefully prepared bed for some object to rest on.
Section—A geometrical representation of an object or building divided by a vertical plane.
Servient tenement—In the case of an easement the tenement on which the obligation is imposed.
Setting-out rod—A board or boarded surface on which work is set out full size.
Settlements—Failures due to the unequal sinking of parts of a building.
Shoring—Temporary timber supports to a building during alterations or when it shows signs of failure.
Site—The plot of ground on which a structure is to stand.
Soffit—The under surface of a vault, arch, or horizontal member.
Span—The clear distance between the supports of a beam or arch.
Specification—A detailed description of the materials and workmanship to be used for any structure.
Spiral stair—One consisting entirely of winders.
Splay—The inclination of one side of an object obliquely to the adjoining side.
Stop—The finish to a moulding or chamfer.
Story—A complete stage in a building extending from one floor to the next.
Superstructure—The upper part of a building carried in the foundations.

TEMPLATE—A metal mould used for cutting masonry and by plasterers in sticking mouldings.
Tie—A member uniting two bodies having a tendency to diverge.
Tobin ventilator—A tube for introducing external air into a room at a suitable level.
Trammel—An instrument for describing an ellipse.
Transepts—The transverse portions of a cruciform building.
Transom—An intermediate horizontal member of a frame.
Trefoil—An ornament having three cusps.
Turret—A small tower often placed at the angle of a wall.

UNDERPINNING—Temporarily supporting a structure with dead shores; extending an existing wall to a greater depth with new foundations.

VALLEY—The internal angle formed by the meeting of two adjacent sides of a sloping roof.
Vault—The arched roof over an apartment; applied also to a vaulted cellar.
Verandah — A light external open gallery attached to a house, and with a sloping roof.
Verges—The edges of the covering of a roof projecting over a gable-end.

WAGON-HEAD VAULT — A cylindrical vault slightly stilted.
Weathering—The covering or special form given to the upper surface of walls or projections on a building to throw off water falling on it.
Well-hole—The open space in a staircase around which the flights are formed; an opening in a floor below a skylight.
Wings—The side portions of a façade or building subordinate to the principal and central portions.
Working drawings—Drawings showing details of a design and serving as instructions to the several artificers.

MATTER, FORCE, AND ENERGY

What is Matter? The Shattered Theory of the Atom. The Essential Property of Matter. The Nature of Electrons. Energy and Electricity.

By DR. SALEEBY

ONLY at the very end of our course shall we discuss the details of the new theory concerning the *structure* of matter. But here we must consider an even more fundamental question—one which has necessarily occupied some of the attention of all the greatest thinkers of the past.

Definitions of Matter. Let us begin, then, by considering some definitions of matter, and thereafter we shall be in a position to see whether we can comprehend the essential nature of the thing defined. The definition of matter that might be given by anyone who had not previously considered the subject would probably be that matter is a *hard* thing, a thing that can be felt, a thing tangible, palpable. Such a man would probably hesitate to call the impalpable air matter. But of course the matter of which water is composed does not cease to be matter whether the water happens to exist in the form of ice or liquid water or water-vapour at any given time. Our idea of matter must include its solid, liquid, and gaseous forms alike.

At the other extreme from the most simple and superficial notion of matter is the definition of the sceptical philosopher, John Stuart Mill, that all we can say of matter is that it is a "permanent possibility of sensation." Whatever that definition may be worth in certain connections, it is of no use to the physicist. A definition which promises to be more satisfactory, and which was long thought to be adequate, is that "matter is that which occupies space." In other words, the essential property of matter is the property of extension—*i.e.* of being extended or of occupying space. In the last resort it was thought we must conceive of matter as a something which takes up room, something no two portions of which can occupy the same space at the same time. It must be impossible to run two portions of matter into another, as the photographer makes a "composite photograph." In other words, matter is impenetrable. A given portion of it may have gaps in its substance into which other portions of matter may be inserted; but where one piece of matter is, another cannot be. "Matter is that which occupies space."

The Atomic Theory. This definition was quite consonant with that atomic theory of matter which until only the other day was thought to be absolutely and ultimately true, whereas now it is known to be only relatively and proximately true—true up to a point. It was thought that matter consists, in the very last analysis, of tiny atoms (a Greek word which simply means that which is indivisible or cannot be cut), and these atoms were conceived as hard, solid little bodies, of various sizes and shapes, like exceedingly small grains of sand. Clerk-Maxwell likened them to "foundation stones": they were "the foundation stones of the material universe, which have existed since the Creation, unbroken and unworn." Like grains of sand, these atoms had the prime character of extension—they occupied space: where one atom was, no other atom could be.

There was another and a profounder way of conceiving these atoms. It might be said that their prime character was the possession of *mass*. Here we may conveniently define this term and distinguish it from *weight*. The weight of a body is a consequence of the law of gravitation. A pound-weight transferred to the moon would still contain the same amount of matter as before, but it would weigh far less, since the force of gravitation exerted by the small moon is much less than that exerted by the earth. On the surface of Jupiter, which is many hundreds of times as large as the earth, the same pound-weight would tax the strength of the strongest to support. On the surface of the sun not even the strongest could lift it. Nevertheless, though the weight of this piece of iron varies according to the force of gravitation,* there is always the same amount of stuff in it: and we express this character by the term *mass*. The mass of a body is a thing absolutely invariable, and would persist even were gravitation abolished, so that it ceased to have any weight at all.

Inertia. It has been said that the prime character of matter is *mass*. This, however, as will be evident to the reader, does not tell us very much; indeed it begs the whole question—for what gives the matter its mass? But this fundamental property of matter may be expressed in another way. It is a characteristic of matter, as we shall subsequently see, that when at rest it will remain at rest until some force is applied to move it: and when in motion, as Galileo first proved, it will continue in motion, in one straight line, for ever, at one constant speed—unless some force is applied to arrest or accelerate or divert it. This property it is from which we have really derived our notion of mass; and the technical name for it is *inertia*. The reader must not imagine that inertia means a tendency to remain at rest when at rest or to come to rest when in motion. Inertia means

* So delicate are the balances employed by modern physicists that it is possible to detect the difference in weight of two cubes of metal, according as they lie side by side in the scale-pan or one upon the other. In the latter case, they weigh less, since the uppermost one is further from the earth, and is, therefore, subject to a weaker action of gravitation.

the property of matter in virtue of which it goes on doing what it is doing, goes on resting when at rest, goes on moving in a straight line at unchanged speed when in motion. Now physicists have agreed that this inertia is really the essential property of Matter.

The Nature of Electrons. This granted, let us anticipate the conclusion of the whole argument, and take it that we must direct our attention not to the atom but to the *electrons* or *corpuscles*, of which atoms are now known to be composed. The ideas which we have formerly entertained of the atoms may be readily transferred to the electrons. *They* are presumably indivisible, it would seem that they occupy space, and they have *mass*. The mass has been measured, and is found to be constant in all electrons. Since they have mass, they have *inertia*, which, as we have learnt, is really the very property of matter that gives rise to our notion of mass. But it is found that these electrons have electrical characters; they are charged with what is called *negative electricity*. [See ELECTRICITY.] At first it was said that they *carry* a charge of negative electricity. Then physicists began to see reasons for doubting whether there was anything there but the charge of negative electricity; whether, indeed, the electrons do not consist of *units* or *atoms* of negative electricity. The inertia which has been agreed upon as the essential character of matter was found to be a property of electricity; it was found to be none other than *electrical inertia*.

So it became necessary to conclude—since matter, to use the words of Mr. Balfour, had been "not only explained, but explained away"—that matter is *made of electricity*, or is merely an electrical phenomenon. Hence the question arises—What, then, is electricity?

Without trespassing upon the subject matter of another course, we may here briefly say that electricity is none other than a mode or form of energy. It can be converted into other forms of energy, such as heat and light; and they can be transformed into it. In other words, matter is merely *a particular form of energy*.

Can Matter Be Transformed? Now, if this be so, if the most fundamental character or property of matter can be identified as a property of electricity, we must ask ourselves whether matter, like other forms of energy, can undergo transformation. This, as we have seen, the physicists of thirty years ago summarily denied. They declared that the units of matter had "existed from the Creation, unbroken and unworn"; that they had upon them the stamp of the "manufactured article." But before this time Herbert Spencer had advanced a theory that everything evolves—the theory of universal evolution; and from this process he did not even exempt matter. When the new theory of matter—that it is a special mode of manifestation of energy—was framed, it became evident that we must seek for proofs that matter, like other forms of energy, can undergo change, or evolution. The fact that such change has been demonstrated may be indicated by the title—"The Evolution of Matter"—of a book lately published by the distinguished French physicist, M. Gustave le Bon, to whom we really owe the pioneer work in our new views of matter.

This leads us to a very serious criticism of a dogma dear to the chemists, and believed by all until within the last year or two—the dogma of the "Conservation of Matter." In the course on CHEMISTRY the reader will see the reasons for believing that, so far as the purposes and experiments of the chemist are concerned, that dogma may be regarded as true. But it can no longer be regarded as *ultimately* true by the physicist. He, as we shall see, believes in the *conservation of energy*, and therefore in the conservation, or indestructibleness, of that of which matter is a particular manifestation. But, in the light of the recent study of radium and radio-activity, he can no longer believe in the conservation or permanence of that particular manifestation of energy which we call Matter.

The "Persistence of Force." A remarkable instance of the insight that belongs only to supreme genius is afforded in this connection by the book, "First Principles," which was published by Herbert Spencer in 1861. Therein he insisted that the physicists of the time were wrong in not recognising that matter is a manifestation of an underlying power or force. He therefore declared that the doctrines of the conservation of energy and the conservation of matter should properly be included in one doctrine, which he called the *persistence of force*, meaning by force the power which is variously expressed as matter or light or electricity or any other form of energy. Spencer's phrase cannot now be used, since the meaning of the word force has latterly been limited and changed, as we shall see: the term energy has taken its place. But now that matter has become as clearly understood by the physicists as it was forty years ago by the great philosopher, we see that the phrase, conservation of energy—to be dealt with fully in its proper place—must now be taken to mean exactly what Spencer meant by his phrase "the persistence of force." Quite lately, Professor Haeckel, of Jena, announced his discovery of a "Law of Substance," which is a somewhat mutilated form of Spencer's law of the persistence of force, or, as it is now called, the conservation of energy.

What Is Energy? When he has read the following chapter, the reader will discover the paradox that, though we now have a far truer comprehension of matter than our fathers had, yet we recognise that we know far less about it than they thought they did. To say "Matter is a form of energy" is easy; but to answer the ensuing question, "What is energy?" is impossible.

Those students of physics, however, who are interested in even greater things than physics will note that the latest knowledge of science is completely incompatible with that doctrine of

materialism to which science has been falsely alleged to lead, but which the most recent advances of science have rendered completely untenable. We may remember, however, in justice to the greatest thinkers of the nineteenth century, that none of them subscribed to the doctrine of materialism. It was by lesser men that this doctrine, now so utterly disproved, was advocated.

It would be pleasant at this point to anticipate the detailed consideration of the greatest idea in physics, the idea of energy. But both on historical and on logical grounds it will be better to concern ourselves first with those facts upon which the idea of energy and the great assertion of its conservation or indestructibleness are based.

Definitions of Technical Terms. At the outset we are faced with an array of technical terms, each of which seems to demand explanation. But, as so often happens, we find on examination that many of these terms overlap or reduplicate one another: and we shall rigidly reject all that are superfluous, since, if superfluous, they are worse in that they make for confusion.

The name still generally given to the primary science of force—which is all-important and soon to be defined—is *mechanics* (from the Greek *mechanē* = a machine); and the terms *theoretical* and *practical mechanics* are often employed. But there are good reasons for confining the word *mechanics* to the study of forces on and in machinery. This use agrees with the obvious derivation of the word; it averts the need for the use of the qualifying adjectives; and it does not interfere with the proper use of a much more suitable word—*dynamics* (from the Greek *dunamis* = force). If we follow, as we well may, the classification suggested in one of the last articles written by Clerk-Maxwell, we must divide the whole subject of physics into two main groups, of which the first consists of the fundamental science of dynamics. All the other branches of physical science are secondary to this; and it is the great contemporary achievement of physics to show that this science is fundamental, that all the other branches of physical science, without exception, depend upon it, and are ultimately referable to it. The laws of light and heat and electricity, for instance, must ultimately be shown to depend upon, or, at any rate, to be absolutely conditioned and qualified by the laws of dynamics. Physics will have reached perfection, in so far as any human science can be perfect, when the fundamental science of dynamics is able to express, in accordance with its laws, all the facts of all the special branches of physics—the movements of the stars and atoms and the ether, the phenomena of light and sound and magnetism.

What Dynamics Is. Dynamics, then, is the science of forces or force; and we must clearly understand, if possible, what is meant by the term. The use of it in English is as a translation of the Latin word *vis*, which was used by Newton in the first book of his masterpiece, the *Principia*. Newton's definition is that, "Force is that which changes or tends to change a body's state of rest or motion."

Evidently, then, the word has a narrower meaning than that which we now attribute to the word energy, for we have seen that the *bodies*, or portions of matter which are acted upon by forces, according to Newton's definition, are themselves to be regarded as manifestations or forms of energy.

Force and Energy. We shall make no progress to a clear understanding of the subject, unless we proceed to distinguish between use of the word *force* and that of the word *energy*. In the whole realm, not merely of physics but of science in general, there has been, and is, no confusion more widespread or unfortunate than the confusion between these two words. To take one instance from thousands, we may quote a sentence which has been used during the last few months as the basis of an important argument, "No power, no energy, is required to deflect a bullet from its path, provided the deflecting force acts always at right angles to that path."

The statement is utterly false, and is, indeed, a flat contradiction of Newton's first law of motion, soon to be discussed; but the absurdity of it is best seen by transposing the words *force* and *energy*, and then reading the sentence again. It contains, of course, a flat contradiction, not only of the most certain law in physics, but of itself. The author has not begun to understand the elements of his subject. But he is not peculiar; the misunderstanding is all but universal. This is partly due to the fact that the distinction requires care for its detection, and to the fact that it has not, until lately, been properly insisted upon by writers on physics, but it is also due to the fact that our use of the word has not been constant in the past. The words have been used synonymously.

Energy includes Force. What we know as the law of the conservation of energy used to be called the law of the conservation of force; and, in ordinary speech and writing, the terms *energy*, *force*, and *power* are all used as if they were synonymous. It would be much better if men would content themselves with the word *power*, which has no very special uses in science, outside mathematics: and if, when using the others, they either stated clearly that they were using purely metaphorical language, or else observed the scientific distinction between them. If this long homily has not been effective we can only regret that we did not make it ten times longer. But the reader will surely have only himself to blame if he falls into the common error after reading this chapter.

The word *energy*, as we shall see in due course, is now used to describe that which is really the underlying and essential fact of all phenomena save those of mind. Certainly this includes the phenomena of motion; and hence the *forces* which are studied by dynamics are manifestations of energy. That is to say, energy includes force, but is immensely wider in its

meaning. Forces are forms of energy, and the study of forces thus throws much light on energy; but though the relations between the two terms are so intimate they must always be distinguished.

The Two Forms of Energy. We must anticipate a little, and observe that energy is displayed in two forms, called *potential* and *kinetic*. Potential energy is as real as any other; but it is latent or unexpressed in anything obvious. *Kinetic energy*, on the other hand, is the energy possessed by bodies when they are in motion (from the Greek *kinesis* = motion): and this kinetic energy they possess in virtue of the forces which have produced that motion.

Now, before he reads a line further, the philosophic reader will insist that he be presented with some account of what we mean by motion. The shortest possible definition of force is "that which changes the motion of a body"; and so it is plain that we have not completely defined force until we have defined motion, since our idea of the one depends entirely on our conception of the other.

Motion may be of two kinds, and every motion of every body, complicated or simple, consists of one or other of these, or of a combination of them. They may be illustrated by the case of the earth. The earth moves *onwards* round the sun; and that is a motion of *translation* (literally, "carrying across."). But the earth also moves round and round on her own axis; and that is a motion of *rotation*. If the earth's motion of translation ceased, we should still have night and day, due to her continued motion of rotation, but we should have no seasons. If her motion of rotation were to cease, we should still have our seasons, but the changes of night and day would cease.

The Two Kinds of Motion. Thus the earth illustrates a comparatively simple case of combination of the two kinds of motion. But the case is not really so simple after all, for astronomers have shown that the sun and his family, of whom the earth is a part, are moving as a whole through infinite space at the rate of about twelve miles a second. No one knows whether this motion is in a circle or in a straight line or in any other of the infinite number of possible directions, but it is certainly occurring. Hence the earth has really two movements of translation—one round the sun, one with the sun to unknown regions—and one of rotation. Indeed, she has many more, but let us take an illustration which the writer has already employed elsewhere. Let us consider the case of one of the corpuscles or electrons that go to compose an atom on the surface of the moon.

Complicated Motion. This corpuscle partakes of the following motions at any rate, and probably of many more. It is moving within the atom, probably revolving round the centre of the atom as the earth revolves round the sun. The little corpuscle may also be rotating on its own axis, as the earth rotates on hers. The corpuscle also partakes of that vibratory or to-and-fro movement of the atom as a whole, which constitutes what we call heat. It is also being drawn gradually towards the centre of the moon as she cools and shrinks. It is also in motion as the moon rotates on her own axis. It is also in motion as the moon revolves around the earth. It has another motion due to the fact that the moon accompanies the earth in her revolution or movement of translation round the sun. And, finally, this tiny corpuscle is moving, with the atom of which it forms a part, and with the moon and the earth and the sun, through space—apparently towards the bright star Vega, familiar to every stargazer as the most prominent star of the constellation Lyra. In addition, it is quite probable that the solar system and Vega and all the other stars we know are in motion together, as a gigantic whole, through boundless space.

Our illustration is more impressive than that often quoted, of the man who walks backwards along the deck of an onward-moving ship—which, in its turn, partakes of all the movements of the earth. Let us consider the corpuscle in the atom on the moon; or the man on the ship. Though each partakes of all these motions and many more, yet we cannot but believe that each is moving only in one direction in space at any given moment of time. The *resultant* of all the forces impressed upon the man or the corpuscle is that he or it has an absolute motion in a certain direction at a given moment—as a consequence of the interaction of all the various motions which we are able to recognize. But it is plain that no one can say what the absolute motion of the man or the corpuscle actually is—at what rate or in what direction.

Limitations of Knowledge. Thus we have placed ourselves in a position to see one of the most profound truths that we can recognise—a truth of equal importance to the physicist and the philosopher. This truth is that we know nothing whatever as to the absolute motions of bodies in space, but only as to their relative motions. We can say positively that a train is moving at the rate of sixty miles an hour. But, indeed, the train is moving eighteen miles a second in one direction, with the movement of translation of the earth; twelve miles a second in another, with the movement of the solar system as a whole; a thousand miles an hour—if at the equator—in another, with the movement of rotation of the earth, and so forth.

To be continued

A SURVEY OF MUNICIPAL CAREERS

The Sphere of Municipal Activities, showing the Scope for Careers in Local Government. Local Authorities of London and the Country.

By ERNEST A. CARR

Local Government of the Kingdom. The amazing growth of the Municipal System was briefly traced in the first article in this Course. In its present form this branch of our great Civil Service is a very elaborate and complex organisa ion, covering the whole country with a network of local authorities of various grades and differing powers, such as the Boards of Guardians, District Councils, corporate Boroughs, and County Councils. During the course of our scrutiny of the Municipal Service we shall frequently have to refer to these and other local bodies; and it is absolutely essential for any practical understanding of the subject that some clear idea of their powers and duties should be gained. Let us therefore consider briefly the way in which the administration of local interests is parcelled out among them.

Least among all local entities—the units of the system, as it were—are the parishes, which are grouped into urban and rural. Of these, the urban parishes have practically no separate administrative existence; they are banded together into larger districts, as will be presently explained. Rural parishes with a population of less than 300 are managed by that simplest of municipal bodies, the Parish Meeting. Its powers are limited to the lighting of the parish and the establishment of public libraries, baths and wash-houses.

The Small Elective Bodies. Rural parishes of over 300 inhabitants are entitled to elect their own *Parish Councils*, which have power to appoint only two paid officials, the clerk and assistant overseer and the parish lamplighter. It is the first rung in the ladder of self-government—the beginning of local authority, offering the first opportunity that comes to a country boy of a post in the public service near his own home.

Next above this tiny model of local government stands a much more influential body, the *Rural District Council*, which employs a staff relatively small but comprising remunerative positions. In addition to clerks, collectors and assistants, the Council employs a medical officer of health, surveyor of highways and sanitary surveyor or inspector, numerous foremen and roadmen, and, in certain instances, a hospital staff besides. In more populous areas the urban parishes are associated to form an urban district, under the control of the *Urban District Council*, an elective body, like its rural neighbours, but enjoying considerably grea'er powers.

The Urban District Council derives most of its authority from the Public Heal'h Acts. Its duties, like those of other municipal bodies, are in part obligatory, in part optional or adoptive. Among the former are the enforcement of sanitary measures, the scavenging of roads, the maintenance of all highways in its area except the main roads, the protection of public rights of way, and the task of enforcing the Acts relating to factories and workshops.

Its optional powers are far wider. The District Council may undertake sewage works, establish libraries, hospitals, parks, markets, baths and wash-houses, and undertake waterworks, gas works, and electrical generating stations. It may make new roads, form cemeteries, and frame regulations and by-laws on an endless number of matters affecting the health, comfort, and safety of the district. It has large borrowing powers for works of a permanent nature, and may promote private bills in Parliament for the furtherance of local needs. If the district numbers more than 20,000 inhabitants, its council (under the Education Act of 1902) is the local authority for maintaining and enforcing elementary education. As a precaution against irregularity in expenditure, the District Council's accounts and those of all larger municipal bodies are audited each year by an auditor appointed by the Local Government Board—a branch of the National Civil Service created expressly to supervise the actions of local authorities.

Town and County Councils. The Town or Municipal Council stands at the summit of local self-government. It has all the powers enjoyed by an urban district authority, and many others besides. In the case of a smaller borough, it may be controlled by the county authority and be dependent on that body for its police and elementary education, and the maintenance of its main roads; otherwise the corporation is entirely self-controlled, and (subject to cer.ain legislative restrictions) administers local needs exactly as seems good in its own eyes.

It would be tedious merely to name the many duties entrusted to the Town Council. It is empowered to erect a town hall and other municipal buildings, to provide hospitals, parks and markets for the people, to deal with nuisances and sanitary measures of all kinds, to make by-laws innumerable, and generally to take what steps seem necessary "for the good rule and government of the borough." The larger corporations boast a stipendiary magistrate, maintain their own police force under the control of a watch committee of the council, and are entrusted with the important duties connected with elementary and secondary education.

Certain ancient corporations—such as Berwick, Exeter, and Norwich—have preserved from of old what are known as "county rights," making them wholly independent of the county authorities.

The County Councils. All boroughs with a population of over fifty thousand were raised to the status of County Boroughs by the Local Government Act, 1888. In each case the governing authority is known as the *County Borough Council*, and possesses the powers of a county authority as well as those of a municipal corporation. Many of the boroughs and county boroughs enjoy special privileges of their own, either by statute or by charter.

The County Councils are elective bodies acting for the several counties, except the districts of the county boroughs. Their very responsible duties in respect of main roads and education have already been mentioned. They also control the county police, maintain local lunatic asylums, reformatories and industrial schools, prevent river pollution, receive the county rate, grant licences for music and dancing, as well as for theatres and racecourses, and enforce certain statutes and by-laws. Lastly, they are required to regulate and supervise generally the work of the various local bodies within the county. For all these duties a large professional and clerical staff is needed.

Apart from the Poor Law and the special characteristics of London, our brief survey of local government in England and Wales is now complete. It may be useful to add the number of local authorities of the several grades described. They are as follow:

Parish Councils	6706
Rural District Councils	672
Urban District Councils	817
Town or Borough Councils	250
County Borough Councils	66
County Councils	62
Total	8573

Scotland and Ireland. Scotland and Ireland were not affected by the Municipal Corporations Act of 1882 and the Local Government Acts of 1888 and of six years later—the three statutes that have swept and garnished the English municipal system. And although each country has since been remodelled on somewhat similar lines, their internal affairs remain, perhaps, less effectively administered and less under popular control than in England.

In Scotland, for instance, the county authority is vested in a council not unlike its English model, but without aldermen, and possessed of fewer powers; whilst sheriffs, appointed by the Crown, exercise certain functions which, south of the Tweed, are vested in elective bodies. The Scotch corporations or burghs are, if anything, more powerful and more democratic in organisation than the English.

One curious feature of Scotch town councils is their control of the "Common Good Fund"—the common purse of the borough, which is readily available for any objects directly beneficial to its inhabitants. English corporations, with their strictly guarded finances, and the fear of "surcharges" always before their eyes, would welcome this characteristic of the towns beyond the Tweed.

A Model for Municipalities. Without discussing Scotch local government in detail, it will suffice to add that, in its leading cities at least, it is generally acknowledged to be strikingly successful. Glasgow, for instance, stands as a model of municipal courage and foresight. In the words of an expert, "The Corporation has carried out bolder schemes and undertaken greater and newer enterprises than any other public body. The vast improvement scheme which began in 1866 has revolutionised the physical and moral condition of the people. Beginning with the clearance of the most insanitary areas and the most densely crowded centres of the city, the Improvement Trust constructed wide streets where congested courts formerly stood; it presented the city with a magnificent park; it set an example nearly thirty years ago in the erection of municipal lodging-houses on a large scale; it has carried out great building schemes. The Health Department has adopted an admirable system of sanitary vigilance and beneficent coercion, which has all helped to improve the health and social condition of the people. The introduction of water supply from Loch Katrine was also of incalculable benefit."

Municipal trams, telephones, gas, electric lighting, ferries, baths, markets, slaughter-houses and many other municipal additions to the comforts of life are enjoyed by the Glaswegian.

Incidentally it may be mentioned that these far-reaching activities involve the maintenance of a colossal staff, many members of which enjoy very handsome salaries.

Local Government in Ireland. A clean sweep of the old grand jury system, and of many other municipal privileges and abuses, was made by the passing of the Local Government Act for Ireland in 1898. Internal administration is still very limited, and is hampered by many difficulties and prejudices, but it has been greatly stimulated by the new conditions, and the outlook is more promising than it has ever been. The new Irish system is electoral, resting on the Parliamentary franchise. The counties are divided into urban and rural districts. Of these, the former class comprise six county boroughs, a number of urban sanitary districts raising their own rates and administering the Public Health and Housing of the Working Classes Acts, and certain towns controlled by commissioners instead of councils.

The rural district councils, acting under the control of the county authorities, have very limited powers in respect of public works, water supply, and the Public Health Acts. For their funds they are dependent on the county councils, which levy a general county rate on all save urban districts. Outside these last-named districts the administrative power is mainly in the hands of the County Councils. Irish municipal work is, indeed, still in its infancy. Large staffs and high salaries are almost unknown outside the offices of the county councils and leading boroughs; and although indications of a general advance in local activities are not wanting, it

will be long ere Ireland offers capable municipal officials a field in any way comparable with that afforded by England.

The Rule of London. London not only forms the most striking of object-lessons in the possibilities attending a skilful and enterprising policy of government—it has an especial interest for us as the widest of fields for ambition in the Municipal Service. For both reasons it will be worth our while to select the English capital for a somewhat detailed study of municipal work. From one point of view we shall have to consider the colossal difficulties and problems involved in the administration of so vast a city; from the other, our interest will be rather in the officials engaged in that task—their salaries, duties, and prospects.

Long the despair of municipal reformers, and afterwards the most complex and vital among the many puzzles confronting them, the Metropolis bids fair to be their greatest triumph. The commercial and political centre of the Empire, London stands alone among cities. With a population greater than that of Scotland, an area rated at more than forty millions sterling, and with property and commercial interests of literally incalculable value, it has a supreme claim to sound, bold, well-organised self-government.

Yet that claim has been almost disregarded until within the last 20 years. The town was suffered to grow up as best it could, in a tangle of jurisdictions and interests that strove like weeds in an untended garden. The policy one parish adopted was opposed by its neighbour; and in the absence of any strong central authority, no effective measure for the betterment of London as a whole was possible. Situated in three counties, with a wealthy and independent corporation at its centre, the capital was divided into a medley of parishes, liberties, outlying parochial areas, and other quaint elements of confusion. Lighting, drainage, rating and other authorities acted independently, without any regard for uniformity or system. The old Metropolitan Board of Works, it is true, did something in the direction of street improvements down to its timely decease in 1888; but it was neither a strong nor a popular body, and its efforts left municipal London a veritable hotch-potch still.

Creation of the "L.C.C." A great mass of incongruities and anomalies was shattered at a single blow by the Local Government Act of 1888. London was created a county in itself, instead of owing a divided allegiance to Middlesex, Kent, and Surrey; and over the various and often conflicting local bodies was placed a really strong representative authority, the London County Council.

Unlike the Board of Works, which it replaced, this was from the first a body chosen directly by the electors, and its popular character has enabled it to go far in the task of simplifying London government and reducing it to a system. Later legislation has aided this work by abolishing various so-called Commissioners and transferring their powers to elective councils; and in 1899 a statute was passed which operated powerfully in the same direction. Its effect was to replace the vestries, district boards, and other perplexing sub-authorities by 28 Metropolitan Borough Councils, with frontiers such as reasonable men could understand. Finally, in 1903, the Education (London) Act handed over all the powers and belongings of the London School Board to the County Council.

The problem of unifying London is by no means yet solved, however. The County Council has practically no control over the heart of its area—that famous square mile belonging to the City Corporation. Certain other authorities exercise special or local powers within the spheres of the county, city, and borough councils. The Police Commissioners, Thames Conservancy, and Asylums Board are instances in point. There are many Londons, each with differing boundaries—the administrative county, the police area, the Londons of the Post Office, County Courts and Police Courts.

The County Council's Great Work. There are thousands of careers open for young men and young women under the London County Council. It is not easy to convey an adequate notion of the amount and varied nature of the Council's work, for which task it has been equipped by Parliamentary powers considerably greater than those possessed by any other county council in the Kingdom. It expends every year some eight and a half million pounds in the course of its labours. For the education of London's children it employs 21,000 teachers and 1600 other officers. The Council's asylums occupy another 3,600 permanent officials, its tramways 3,000 more, and the remaining departments an additional 5,500, exclusive of several thousand workmen and temporary assistants of various sorts. The total permanent staff of the L.C.C. is thus over 34,000 of all ranks—a larger army than that with which Napoleon won his stubbornly contested victory at Arcola.

This great force of workers is grouped into a number of departments, each in charge of a responsible and highly paid officer, and controlled by an expert committee of the Council. A reference to the activities of those divisions will show very clearly the variety and vastness of the Council's undertakings.

The engineering branch, for instance, numbering 1,314 employees, is occupied chiefly in the gigantic and supremely important task of dealing with London's main drainage. It has charge of 288 miles of main sewers, draining an area of 140½ square miles and discharging almost exactly 250 million gallons daily. When there is added to the labour involved in treating this enormous volume of sewage, the charge of London's bridges, and such occasional engineering feats as constructing the Blackwall Tunnel, it becomes clear that the chief engineer's stipend of £2,000 a year is fully earned.

The Council's Fire Brigade forms an equally large department, justly famed for its smart, well-trained staff, and up-to-date equipment. Including the river section, its services are invoked about a dozen times a day.

Outdoor Careers. The 5,000 acres of parks and pleasure-grounds maintained by the Council need merely passing reference. The works department, with a small permanent staff of building and engineering experts, undertakes numerous works, such as artisans' dwellings, fire stations, asylums, and street-making, upon which over 2,000 workmen are constantly employed. The Public Health branch, under medical experts, supervises the work of the local sanitary authorities, inspects the seamen's and common lodging-houses of London, and punishes any lack of cleanliness, keeps a watchful eye on outbreaks of infectious disease, frames new bye-laws and regulations on Public Health matters, and in many other ways does invaluable work in preserving the well-being of the citizen.

Nowhere has the enterprise of the County Council been bolder or more successful than in the huge schemes of its Improvement Committee for drastic alterations, designed to add to the dignity and usefulness of certain of London's main thoroughfares, and to render the aspect of the capital more worthy of itself. If London's ugly, awkward and narrow streets are becoming things of the past, it is largely due to the vigorous policy of this supreme authority. A great and valuable work is performed by another committee of the L.C.C. in the maintenance of London's 17,000 lunatics and epileptics. The annual expenditure is £520,000, of which no less than £160,000 is devoted to the salaries and wages of the large staff of doctors, nurses, attendants, and other officials necessarily employed in the county's nine asylums.

Under the heading of municipal locomotion we may include the Thames steamboat service, organised in the spring of 1905, the 48 miles of municipal tramways in North London leased to a commercial company, and the 46 miles on the south side of the Thames owned and worked by the Council itself. The Council's tramway policy of low fares and liberal wages has been amply justified by the event. The efforts made by the Council to abolish slum areas, and to provide cheap, wholesome housing accommodation for the working classes in their stead, form another interesting chapter in the long record of its stewardship. Schemes at present in hand provide for the housing of no fewer than 80,000 workers.

Education. There is little need to enlarge upon the educational work of the Council, its latest and most colossal undertaking. The whole system of elementary education has been taken over bodily from its creators, the now defunct London School Board. Briefly, the duties involved are the teaching of 550,000 children in ordinary schools, the maintenance of truant and industrial schools for the wayward and of special centres for the defectives, and carrying on evening schools for manual, technical and domestic education, and for the training of a large staff of pupil teachers. The sum paid annually in teachers' salaries alone already reaches £1,600,000. To this task the new education authority has added a liberal and comprehensive system of scholarships, enabling clever children, however poor their parents may be, to climb the educational ladder to its topmost rung.

Diversity of Work. Other activities there are which must be passed over unnoticed, but our review of the Council's work must not omit the services performed by its "Public Control Department." The work of this department has been admirably summarised by an authority in municipal affairs. "The diversity of its duties" (he writes) "ranges from regulating the feeding of babies to the inspection of dynamite and the control of coroners' inquests. Outside the City, it checks and inspects all weights and measures; tests the accuracy of gas meters, the milk-can and the beer-glass; and ascertains that the coal is of correct weight and guaranteed quality. It protects us (Londoners) from the danger of fire arising from storage of inflammable liquids, and has done its best to secure the safety of petroleum lamps—the light of the poor. It extends its protective influences to the animal world, and stamps out contagious diseases in horses, cattle, and other animals."

By such varied means the greatest of the County Councils is occupied in protecting its citizens and making London the best governed city in the world. The officers employed to carry out its designs are liberally remunerated for their efforts. The Council's pay-list includes five posts of £2,000 and twelve others at figures between £1,000 and £1,500. There are numerous appointments carrying intermediate salaries, down to the £500 which represents the maximum attainable by staff officials not singled out for special promotion.

The Borough Councils. Since 1899 the local control previously exercised by the London vestries and district boards of works has been in the hands of certain special authorities created by the London Government Act of that year. These Metropolitan Borough Councils, as they are called, have certain characters distinguishing them from the general Borough Councils of the provinces. As sanitary authorities they possess special powers under a Public Health Act limited to London. They maintain all main roads in their area, may undertake street improvements, and may promote bills in Parliament. Generally, however, their work resembles that of the county borough authorities described earlier in this Course; but the Metropolitan boroughs, as a rule, require the services of a larger staff, and their average level of remuneration is higher than prevails in the provincial offices.

An analysis of the actual figures relating to the staff of a typical Metropolitan council office (without electrical works) gives the numbers employed as follow:

Surveyors' Department	50
Rating and Registration	32
General Staff	35
Libraries	35
Public Health Department	17
Burials Department	6
Total	175

The salaries include that of Town Clerk, £1,150; Solicitor, £750; Medical Officer of Health, £1,000; Surveyors (two), £750 each; Public Analyst (by fee), about £400; Accountant and Valuer, £330 and £300 respectively. Among the clerical staff, the highest post carries £420, the rank and file rising by regular increments to £200. Sanitary inspectors reach about the same maximum. The four leading librarians receive respectively £350, £250, £230, and £150, with a residence apiece; whilst the remuneration of the rate collectors varies from £230 to £160 a year. These figures will serve to indicate the wide scope afforded by the offices of the twenty-eight Metropolitan Borough Councils.

The City Corporation. In the very heart of modern London, with its newly created authorities, exists the most ancient and famous of all municipalities, tracing its history back nearly a thousand years. The position of the City Corporation is singular on more than historical grounds. Geographically its area is insignificant—a mere 672 acres, or just over a single square mile, which is about one-seventh the size of Camberwell Borough. Yet it is by far the wealthiest and most influential corner of London—the capital's commercial capital.

The City is governed by a Court of Common Council, composed of the Lord Mayor, 25 Aldermen, and 206 Common Councilmen. The Lord Mayor himself is elected each year from and by the Court of Aldermen, on the nomination of the Livery. The Common Councilmen are appointed annually by the votes of the Livery, which is an electorate composed of members of the ancient Trade Guilds or Mysteries. Each of the guilds was originally a defensive association of traders engaged in the same calling, though nowadays members of the Armourers', Girdlers', Bowyers', or Patten Makers' Guild would be puzzled if called upon to exercise their craft.

Municipal Posts in the City. Always an independent county as well as a municipality, the Corporation, though it has so far yielded to modern influences as to admit the London County Council to some share in its administrative control, still preserves many of its quaint and unrivalled privileges of self-government. It elects its own Sheriffs, has its own Commission of Lieutenancy and Justices of the Peace, and its own Courts of Law. More singular still, it possesses a body of police which (says that expert in matters municipal, Mr. Robert Donald) "is the only really municipal police force in the country, as it is independent of the Home Office."

For almost all purposes of administration the Court of Common Council appoints its own staff of officials. It controls the five principal markets in London, maintains a museum, art gallery and several important schools, owns four of the bridges over the Thames, and lights, paves, and cleanses in faultless fashion the streets within its area. Most important of all, the City Corporation is the port sanitary authority of London, exercising sanitary rights from Teddington Lock to beyond the Nore, and maintaining a special medical officer and a staff of inspectors to prevent contagion from entering the Thames.

The majority of City appointments are made or approved by the Court of Common Council or its committees. In respect of salaries the Corporation is certainly the most liberal municipal employer in the Kingdom. Of its relatively small staff, eight officials receive £2,000 a year or more, and nine others are paid from £1,000 to £1,500. The stipend of the Clerk to the Lord Mayor is £1,150, and that of the librarian, £850; whilst the responsible office of sword-bearer is remunerated with a salary of £600.

London's Minor Authorities. To complete our review of London government we must glance at one or two minor authorities, whose work is restricted to a few special functions. The foremost of these is the Metropolitan Asylums Board, a central authority created for the reception of insane paupers, and of those suffering from smallpox and other infectious diseases. It has long outgrown its original scope, however; and besides maintaining five imbecile asylums and two schools for afflicted children, possesses twelve fever hospitals, at which other than pauper patients are admitted. It also maintains a training ship for workhouse boys, an ambulance service over the whole of London, and several other undertakings. The appointments under its control are chiefly medical, nursing, and domestic.

London is singular among towns in that the control of its huge police force—except in the City proper—is neither municipal nor county, but is vested in a separate authority, the Commissioners of Metropolitan Police, who are amenable only to the Secretary of State. They play no other part whatever in the government of the capital.

The Metropolitan Water Board is a recently constituted body composed of representatives of local county, borough and district councils, which has taken over the systems of the eight water companies supplying the Greater London area, in order to manage them in the interests of the ratepayer.

The River. The last of the special authorities to be considered, the Thames Conservancy Board, is another assemblage of representatives of various local and national interests, with a sprinkling of trade delegates. Its functions are of vast importance to that waning feature in commercial life, the Port of London. Briefly, they are to maintain the river in an efficient state for navigation, and to prevent its pollution. For these purposes a large staff of inspectors, river keepers, boatmen and other waterside officials is constantly employed.

To be continued

A WOMAN'S CHOICE OF A CAREER

RECENT years have witnessed the entry of women into many fields formerly deemed to be exclusively for men. These details regarding some of the principal careers for women may help to solve the problem, "What shall we do with our girls?" The full courses in the SELF-EDUCATOR concerning each profession should be consulted by all who would enter upon any of these careers. Some available careers which are equally open to both sexes are not touched upon here, as they are noticed in a previous article on page 161; and for other openings not included in this summary the reader is advised to consult the fuller sections of the SELF-EDUCATOR.

Accountants. For women with an aptitude for figures, there are openings as accountants and auditors. The training is the same as for men. The candidate should be sufficiently well educated to pass the preliminary examination of the Institute of Chartered Accountants, although membership of that body is still denied to women. She should be articled to an accountant for five years, and pass the three prescribed examinations. The cost of training is from £100. Age limit from 18 to 21. Women are frequently employed to audit the accounts in girls' schools and colleges. [See pages 148-9.]

Bookbinding. This is work which may often be done by women in their own homes A thorough training is necessary, as well as artistic instincts. A twelve months' course of training costs about £70. It is fairly remunerative.

Chromo-lithography. Three years are necessary to become fully acquainted with the work. There are many openings both at home and in the Colonies for workers who are well qualified. Salaries average from 20*s.* to 35*s.* a week.

Church. In the United States hundreds of women have been ordained, and are practising as ministers, but there are, so far, no openings of the kind in the United Kingdom, although one lady has recently been appointed pastor of a church in a provincial town. A number of women find employment as church workers, but this work is never well paid. Bible women, when trained at one of the homes in connection with various charitable organisations, are paid from £40 to £60 a year. The Church Army Mission nurses are paid 14*s.* a week, with lodging.

Civil Service. An increasing number of women find employment as clerks in the Civil Service, chiefly in the various branches of the Post Office. Posts are obtained by open competitive examination, in which a high standard of proficiency must be attained, as competition is very keen. The examination is in the usual English subjects and two foreign languages. Fee 7*s.* 6*d.* The age limit for women clerks is from 18 to 20, salary to begin £55, rising to £100 per annum. One month's holiday is given, and a pension or gratuity on resignation. For girl clerks, the age is from 16 to 18, and the beginning salary £35. At the end of two years they may be promoted, if competent, to the rank of women clerks, starting at a salary of £55. Female sorters in the Post Office pass an examination in English. Age limit 15 to 18. Salary begins at 12*s.* a week and rises to 21*s.* 6*d.* Between the ages of 18 and 25 sorters may enter the open competitive examinations for women clerks. The security of tenure, short working hours, and length of holidays, together with the prospect of a pension, make this a very desirable career for women.

Commercial Travellers. A few women are employed as commercial travellers in England, and a much greater number are doing well as such in the United States. The posts obtained in this country are chiefly in connection with the drapery trade, and are usually given to employés who have shown special ability and are well acquainted with the business of their firm.

Dairy Work. The training at one of the dairy schools recognised by the Board of Education lasts from six to twelve months, and costs about £1 to 30*s.* a week, including board and residence. Salaries paid to dairy teachers under the county councils range from £1 5*s.* to £3 a week. Superintendents of dairies on private estates are paid from £25 to £60 a year with board and residence.

Dentistry. There are few women dentists to be found in England, although numbers are practising in the States and Canada. The Royal Colleges of Surgeons of Dublin and Edinburgh grant the diploma in Dental Surgery to women, who may then be registered for practice by the Medical Council. The cost of training is somewhat less than for medicine.

Dispensers. The highest training of women dispensers consists of a three years' apprenticeship to a qualified chemist, to whom a fee of from £50 to £70 may in some cases have to be paid. Training and examinations are as for men. [See page 161.] Women have obtained posts as dispensers in hospitals and other institutions at from £80 to £150 per annum. There are also openings as dispensers to medical men, who often accept the certificate of the Apothecaries' Assistants' Examination, together with a course at a school of Pharmacy as sufficient qualification. The average tuition fee for a three months' course at a school of Pharmacy is about ten guineas.

Domestic Science. Technical Education in Domestic Science is a development of quite recent years, and the profession of domestic science teacher is one which is very suitable for an active woman of good education. Training lasts about two years; the cost of the complete course varies from £18 18*s.* to £55. Instruction in cookery, laundry work, dressmaking, millinery and hygiene is given in schools of cookery throughout the country, also in both elementary and secondary schools. Salaries of teachers for these posts range from £70 to £250 a year. There are also posts obtainable under borough councils, and sometimes particularly good colonial

appointments are offered to domestic science teachers trained in England.

Dressmaking. There are always plenty of openings for clever women in dressmaking. Apprenticeship lasts two years. In a good house the premium, if indoors, is usually from £60 to £100, and, if the apprentice lives at home, about £30 to £50. On expiry of apprenticeship a post is usually taken as improver for about six months, when assistants' posts may be obtained at from 10*s*. to 16*s*. a week, rising in the case of a good worker to £2 a week. A really first-rate fitter can obtain £5 a week. Women who mean to start in business as dressmakers should spend at least some months at the practical part of the work, and should understand stockkeeping. To start in London at least £1,000 capital would be necessary, as credit must be given.

Florists. Apprenticeship is usually for three years. During part of this time wages of 3*s*. to 5*s*. a week are paid. Afterwards assistants may earn from 15*s*. to 25*s*. or 30*s*. a week. Premiums of from £5 to £30 are usually paid for learning florists' work.

Gardening. A course of instruction at a horticultural college such as that at Swanley or the Lady Warwick College, Reading, usually lasts from two to three years. Fees are from £70 to £80 a year, including board and residence. Instruction is given in horticultural science, flower, fruit, and vegetable growing (out of doors and under glass), market work, packing and storing. Dairy work, poultry farming, and bee-keeping are extras. When trained, some students obtain positions as lecturers and teachers. Lady gardeners are seldom paid more than £1 a week to begin with. They frequently take resident places as companion-gardener to some lady. To start in business as a market gardener it is necessary to have at least £900 capital.

Hairdressing. In the opinion of some hairdressers there are openings for women in this business. The term of apprenticeship is two years. When the various branches of the work are thoroughly mastered, an assistant can command from 15*s*. to 35*s*. a week, usually with a percentage on all articles sold.

Hygiene. There are many well-paid appointments open to educated women who are trained in hygiene. A certificate may be obtained from Bedford College, London, by students who pass the examination held at the end of one year's course in scientific and practical hygiene. The fee is 27 guineas. A shorter and less expensive course may be obtained at the National Health Society, Berners Street, London. The fees there are 15 guineas for six months. For women so qualified, posts have been held as Factory Inspectors, Sanitary Inspectors, Lecturers under the County Councils, and Inspectors under the Shop Hours Act.

Illustrating and Fashion-Plate Drawings. Many women who have received an art training can command good salaries as illustrators of books, magazines and ladies' papers. This is a profession which is not overcrowded. Women who desire employment of this kind should send sets of specimen sketches to the editors of some of the illustrated papers.

Indexing. Openings for work of this kind are always increasing. Indexing is a lucrative employment suitable for well-educated women. The training under an experienced indexer lasts from six to nine months, and the fees are from 15 guineas. Women indexers have recently been appointed by the London County Council. The work can be done at home. Charges range from £2 2*s*. to £4 4*s*. per thousand entries.

Journalism. The prospects for women in journalism are fairly good. Payment for special or occasional contributions is equal to that of men, although for regular reporting work women are paid less. Women are also handicapped at the outset by their inability to obtain the thorough routine training which is usually gone through by men, but, given a capacity for hard work, they frequently achieve success.

Laundry Work. There is a steadily growing demand for thoroughly well-trained women in laundry-work, both as actual laundresses and as superintendents or manageresses of laundries. The course of training for manageresses in a good laundry usually lasts from three to six months. The fees are from £5 to £10. When the training is completed, if the pupil is thoroughly competent, she may obtain a position as forewoman or assistant manageress at a salary of from £1 to £2 10*s*. a week. The hours of work are long, being usually from 8 a.m. to 8 p.m., and the work is hard. Manageresses are paid from £2 up to £5 a week.

Librarians. There are not so many openings for women as librarians in this country as in the United States or Canada, nor are the salaries paid in England sufficiently remunerative to induce women of good education to take up what would otherwise be suitable and congenial work. The best plan to pursue in order to become a librarian is to attend the classes at the London School of Economics and enter for the Examination of the Library Association. The average earnings of a woman assistant in our public libraries is £50 a year. Head librarians are paid £100.

Medicine. Women who desire to qualify as medical practitioners are subject to the Regulations of the general Medical Council in the same way as men. Women are admitted to medical degrees and diplomas equally with men, by the examining bodies of most British Universities, with the exception of Oxford and Cambridge. Posts are open to women doctors in the Post Office, and under the London County Council; also in connection with many hospitals and dispensaries throughout the country. Many women are earning good incomes in private practice in Great Britain, while, owing to the fact that no man can enter the zenanas of the high-caste Hindoo, India offers a wide field of labour. Appointments are open both under Government and in connection with some of the various missionary bodies, the Dufferin Fund, etc.

Millinery. Apprenticeship lasts two years; at the end of first year wages about 5*s*. weekly. Assistants in wholesale milliners' receive from

12s. to 30s. a week. In the West End shops engagements are often for the season only, when a very experienced hand can command from £2 to £4 or £5 a week. To start in business in London about £400 capital is necessary, also technical training and a taste for the work. For such women the prospects of success are good.

Needlework—Art. At the Royal School of Art Needlework, South Kensington, training lasts two or three years. Fees for two years' certificate course £20 a year, and for three years' diploma course £10 a year. Hand embroidery, etc., is taught to amateurs. Fee for six lessons, 21s. to 30s. There are many other schools of embroidery in London and the provinces. There is a fair demand for work of this kind in connection with churches. It also commends itself to some women as being work which can frequently be done at home.

Nursing. Hospital nurses receive a training of three years in a hospital to which the average age of admission is from 23 to 30. Some hospitals require a fee of from £10 to £50. Probationers are usually paid from £8 to £15 a year with uniform. When the period of training is over the majority of nurses take up private work, usually joining one of the Co-operative Associations of Nurses. In these societies the nurses retain their own fees, only deducting an agreed percentage for expenses. Their salaries average from £72 to £110 per annum. Private nursing may also be undertaken for an institution at a fixed yearly salary, ranging from £20 to £40, with uniform, board and residence. Nurses who join Queen Alexandra's Imperial Military Nursing Service, for work at home and abroad, are paid from £40, in addition to quarters, board, allowance, etc. Sisters receive £50 to £65. Matrons, £75 to £105, and the Matron-in-chief from £300 to £350. They also receive a pension upon retirement. Age for appointment from 25 to 35. In the Naval Hospitals head sisters are paid £125 to £160 in addition to quarters and uniform. Nursing sisters receive from £37 10s. to £50, with board allowance of 15s. a week. District nurses in London or the Provinces are usually trained for two years in a general hospital, and six months in a district nursing home. Salaries from £26 per annum, with everything found.

The training of maternity nurses is usually from three to six months in a maternity hospital or infirmary. Fees for this are usually £10 to £26. The Obstetrical Society of London holds examinations four times yearly, at which certificates are granted to successful candidates. Fee, 21s. A maternity nurse's fee varies from £6 6s. to £21 for a case.

Photography. A course of instruction in photography at the Regent Street Polytechnic costs £52 10s., in addition to which a student should work for a few months as a pupil in some good studio. To start in business in London at least £500 capital would be necessary, although considerably less would suffice for the Provinces. Retouchers in photographic studios may be paid from 25s. to 40s. a week. For working up, 17s. 6d. to £2 10s. a week.

Physical Training. There appears to be a wide and, so far, unfilled field for women of good physique who are thoroughly trained gymnastic teachers. The course should extend over two years, and costs from £50 to £100, exclusive of living, or as resident pupil at a Physical Training College, from £90 a year. Resident teachers in schools are paid from £40 to £50, non-resident teachers from £100.

Printing. Apprenticeship lasts for three or four years, but wages begin after about six months. At the Women's Printing Society a premium of £5 is paid, and a small weekly wage is received from the start. The average rate of pay is 24s. a week, but it sometimes rises to 34s. Women compositors who can spell well seldom fail to find work.

Sanitary Inspectors. The number of appointments open to women under the County Councils is steadily increasing, and the work which has been done by those already appointed has proved satisfactory. The age limit for London applicants is from 25 to 40, and the requisite qualification is the certificate of the Sanitary Inspectors' Examination Board; for the provinces the Sanitary Institute Certificate is accepted. Salaries vary from £80 to £110 per annum, and rise to a maximum of £150.

Secretarial and Clerical Work. Women who, in addition to a sound English education, have undergone a special business training in typewriting, shorthand and book-keeping, can obtain posts at from 30s. to £2 a week. If to these qualifications a knowledge of commercial French and German is added, salaries may rise to £3 a week.

Shop Assistants. Women shop assistants are chiefly to be found in the drapery trade. Age of entering is usually 14 to 16. In the better class shops a premium of from £20 to £30 is often paid. After three years an assistant receives from £12 to £20 a year indoors, rising in the first-class shops to £70, and, in the case of buyers and heads of departments, to £150 a year. A commission on sales is also given in many shops. The hours are long and the work tiring, and, on the whole, the average wages are less than in other occupations.

Teaching. High-school teachers undergo a long and expensive training, usually taking a University degree. Salaries of assistants in a public school are from £50 to £80, with board and residence. Non-resident teachers from £80. In a large private school senior assistants may rise to £140 per annum. Head mistresses of high schools are paid from £180 to £700 a year.

Kindergarten teachers should spend from two to three years in a training college which prepares them for the National Froebel Union Examinations. For teachers so qualified, salaries range from £50 to £100 a year.

In Elementary Schools the training of the women teachers is on the same lines as that of the men. [See page 164.] All certificated teachers pay into a superannuation fund, and are entitled to a pension of £40. This profession is one of the few which are not overstocked.

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THE BEGINNING OF ENGLISH POETRY

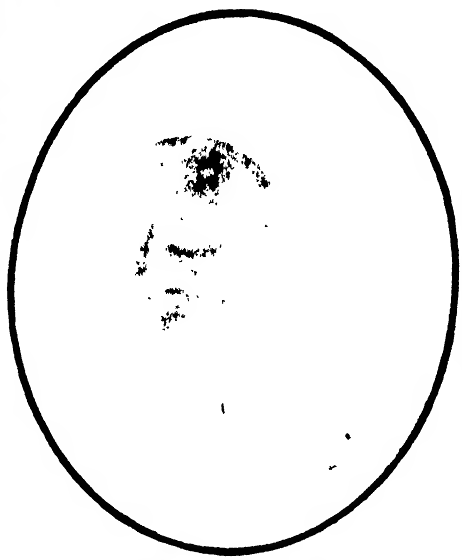
A Short Study of Geoffrey Chaucer and his Work, with an Outline of the Chief Mediæval Poets down to Wyatt and Surrey

By J. A. HAMMERTON

IF one were to begin the study of poetry with the works of GEOFFREY CHAUCER, it is doubtful whether one's progress would be immediate and sustained. For the study of Chaucer requires of the student some degree of cultured love for poetry, which is not so necessary to the immediate enjoyment of Shakespeare or Tennyson.

We mean by this that the reader who as yet has no pretensions to a cultivated literary taste may take up a play of Shakespeare's, a poem of Tennyson's, and fall forthwith under the spell of tho poet's music, his imagination, his wisdom, his humanity, as both of these great geniuses are articulate to us in our daily speech.

But not so with Chaucer and the writers of the later mediæval period. While the body of the language in which Chaucer wrote is the essential English with which we are all familiar, it is different in so many little ways that the reader never quite accepts it as his own tongue, but always finds in it a quaint and somewhat foreign flavour. For this very reason, however, there is the more need that we should familiarise ourselves with the English of Chaucer, as it is with him that our language first attains to classic distinction.



GEOFFREY CHAUCER
After Occleve's portrait

What Chaucer did for English. Some critics, more hasty than wise have condemned Chaucer for introducing so many French words into our vocabulary; and while this complaint may seem at first glance to be capable of ready proof, we have to remember that in Chaucer's day the rude and vigorous Anglo-Saxon speech of the common people had absorbed from the Norman-French of the aristocracy numerous words and idioms not yet quite assimilated, but later to be so, and vastly to enhance the beauty and expressiveness of the language; so that Chaucer was no affected writer, but one true to the speech of his day, which we know as "Middle English." While Chaucer sounds "quaint" to us, he was doubtless as clear and unaffected to his contemporaries as Tennyson to his, clearer than most of our present day poets. Indeed, as Lowell says very pithily: "He found our language lumpish, stiff, unwilling, too apt to speak Saxonly in grouty monosyllables, but left it enriched with the longer measure of the Italian and Provençal poets. He reconciled, in the harmony of his verse, the English bluntness with the dignity and elegance of the less homely Southern speech."

The Need to Read Chaucer's English. We must be at the little pains necessary to the proper understanding of Chaucer's language before we begin to read him, and under no circumstances are we to waste our time on any of those numerous works in which his writings have been "adapted into modern English." Not even Dryden, in his fine version, could help losing much of that Chaucerian simplicity and charm which can be found only in the original, and the trouble of qualifying ourselves for the understanding of that is so slight, that there is no excuse for reading Chaucer in any but his own text, which we have best in the edition so thoroughly edited by Professor Skeat, and indispensable to every student.

Russell Lowell's important essay on Chaucer (in "My Study Windows," of which there are several editions at one shilling) should also be read carefully before proceeding with the study of the poet. Here we can only submit a few rules which will enable the ordinary reader to turn at once to Chaucer with the certainty of finding him surprisingly easy to understand, especially if one has already attempted to read him without knowledge of the principles of metre which he recognised, and which, by the way, are substantially the principles of modern French poetry.

How to Read Chaucer. First of all, we must note that numerous Old French words, since modified in spelling and pronunciation, retained in Chaucer's time a closer likeness to their originals, being in many cases quite un-

altered; for example, "chamber" is chaumbre, "error" is errour, "authority" is auctoritee, and so forth. Then all words ending in "e" have to be read as though this letter formed a separate syllable, except when the word immediately following begins with a vowel, or sometimes when it begins with an "h." Professor Skeat instructs us to sound the final "e" also when it occurs at the end of a line; but, while we cannot question Skeat's authority, it seems to us that if we strictly observe this rule we bring ruin on many lines of Chaucer, which are thus, though written in the iambic pentameter, forced to carry twelve syllables instead of ten or eleven, and crowd his poetry with many needless feminine rhymes. Despite Lowell's belief that there is no imperfect line in Chaucer, it is tolerably certain that even the rule of accenting the "e" was not always observed by the poet when the metre of his verse did not require it. The medial "e" is also sounded as a rule, and thus certain words ending in "ed" or "es" take a syllable more than they require in our modern speech.

Illustrations of Chaucer's Verse. What we have learnt of rhythm in our previous study should enable us to read the lines of Chaucer with that metrical movement the poet meant them to have, and it only remains to add, before giving illustrations, that many of his verbs retain the old German "en," while the past participle has the "y" or "i" prefix, which in Middle English took the place of the old "ge." In the following four lines several of these peculiarities are illustrated:

"Why nil the leoun comen or the bere,
That I mighte onés mete him with this spere?
Thus seyn thise yongé folk, and up they kille
Those hertés wilde, and han hem at hir wille."

It seems to us a distinct weakening of these verses to make each end with a double rhyme, but Dr. Skeat is an unassailable authority on accentuation. The following illustrates the use of the final "ed" and the prefix "y":

"That ever was y-forméd by nature;"

while here is a line that goes against nearly all these rules:

"And liv-ed in joy-e y-nogh; what wold-e mor-e?"

It is possible to make no less than thirteen syllables out of that line as we have marked it; but that is obviously wrong. If we accentuate it according to the rule of the iambic pentameter, in which the poem is written, it reads smoothly thus:

"Ănd lived ĭn jōye ȳ-nōgh; whăt wōldĕ mōre?"

For the general student who is making no effort to become a specialist in Chaucerian or mediæval literature the method we have indicated appears the simplest to follow in scanning Chaucer's verse, and whether it be right or wrong need not trouble him greatly, as it will enable him to enjoy to the full some of the grandest poetry in our language. But, even so, we do not think it wise that anyone should make his first acquaintance with English poetry by reading Chaucer, and we are only dealing with him at this stage as [illegible] by the historical sequence we are observing in our survey. Rather let one's taste for poetry be ripened some little way by acquaintance with Shakespeare or the more modern writers before seriously taking up Chaucer; but, be assured, that Chaucer, once taken up as a task, will be continued as a pleasure.

Chaucer's Characteristics. There is, indeed, no poet more human than Geoffrey Chaucer, hardly one with whom a reader would feel more willing to have had personal acquaintance. The intense humanity of the poet comes out so inevitably in everything he wrote—although his person is never obtruded in any unnecessarily egoistic fashion—his sympathy with his fellows, his delight in Nature's ways, his jovial humour, his reverence, his occasional ribaldry and his sorrows for his follies—all these qualities serve to make his a most lovable personality. In one word, he is a *man*, with some of the failings of his kind and many of its virtues. Lowell refers to him as "a truly epic poet, without knowing it." Although we find in his poems occasional evidence of "absolute dramatic inspiration," which, *were it continuous instead of occasional*, would carry him into the highest rank of the world's great poets, it does seem to us that his inspiration is at least sufficiently egoistic to warrant our regarding him as a narrative poet.

Chaucer's works have been parcelled out into three sections: known as the French period, the Italian and the English. As this seems a somewhat artificial procedure, suggested, perhaps, by the pedantic vanity of some critics rather than by any decisive evidence of his writings, we shall not follow it, but endeavour to state as briefly as possible the few facts with which the young student ought to be familiar.

Influence of Continental Literature. Although a great creative artist, Chaucer's genius was awakened by the influence of Continental literature with which, as a scholar, he early made acquaintance, the French poets and the Italian poets and story-tellers being familiar to him in the original, and largely drawn upon by him for his material. His heaviest debts are to Boccaccio, his great Italian contemporary, whom, as well as Petrarch, he is popularly supposed, on very slender evidence, to have met during a diplomatic mission to Italy. It is also probable that Dante's "Divina Commedia" had considerable influence on him, while his verse-form was derived from the *trouvères* of France, who for more than two hundred years before him had been composing those epic poems which the *jongleurs* carried about in manuscript or in memory and recited in castle halls. Yet, with all his borrowings, and even when he seemed only to have translated, Chaucer so wonderfully transmuted by his genius the material wherewith he worked that it was *re*-created, as is the case with all great artists. Boccaccio himself, from whose "Decameron" Chaucer drew so much for his "Canterbury Tales," and whose "Filostrato" he so closely follows in "Troilus and Criseyde," took his

stories from the popular mediæval fiction of his time, and gave them classical form. But the artist mind of Chaucer is well illustrated in "The Canterbury Tales," where every personage tells a tale that is suited to the teller's character, taste, or condition of life, whereas there is no such dramatic fitness observed in the "Decameron."

"The Canterbury Tales." This, of course, is the work with which the name of Chaucer is always associated in the popular mind. But great though it is in many ways, and absolutely characteristic of the poet, as a composite whole it is doubtful if it can be placed before his "Troilus." The plan of the book is so familiar that it is not necessary to do more than outline it in a very few words. A company of pilgrims, journeying to the shrine of Thomas à Becket at Canterbury, foregather in Southwark at the Tabard Inn, where the poet, himself supposed to be starting on a pilgrimage to Canterbury, meets them and proposes to make one of the company. The landlord of the Tabard also offers to join the party and to act as guide. It is he who suggests that in order to beguile the tedium of the journey each pilgrim should undertake to tell two stories, both going and returning, and that the teller of the story which is voted the best will, on the return to the Tabard, be entertained to supper at the common cost of his or her fellow pilgrims: for the company is of both sexes.

Although Chaucer did not set himself the task of relating every one of these stories told by the pilgrims, who, including the poet, numbered thirty-three, the twenty-four tales and prologues of which the work consists form only a fragment of his design; but a glorious fragment, which for nearly two hundred years remained the unequalled gem of English literature.

The Pilgrims. Surely there never was a merrier company of pilgrims than that which set out from the Tabard, with Harry Baily to guide them, on a journey that had little of penance in it. In the Prologue, which is the very acme of Chaucer's achievement, the characters of the different persons are so vividly drawn that they live again for us in the very atmosphere of the Middle Ages. The tales themselves vary in merit, but the "Knight's Tale" is generally regarded as the finest of the series, and the "Miller's Tale" is perhaps the coarsest. We have no space here to discuss the ethics of the poet's reasoning in his apology for including certain stories more racy than polite:

"And ther-fore every gentil wight I preye,
For goddes love, deemeth nat that I seye
Of evel entente, but that I moot reherce
Hir tales alle, be they bettre or werse,
Or elles falsen som of my matere.
And therfore, who-so list it nat y-here,
Turne over the leef, and chese another tale."

This does seem true enough from the artistic point of view, and from that of historical truth it is equally cogent, for it has to be borne in mind that the poet reflected in his mirror the manners of a rude age, despite the fact that it was the time "when knighthood was in flower." We see no reason, therefore, to suppose he wrote thus "with his tongue in his cheek," as some critics have suggested. As we have already indicated, however, "Troilus and Criseyde" may be considered the fine flower of Chaucer's genius; one of the most perfect works of poetry in the English language.

Where to Begin. But it is neither with "The Canterbury Tales," nor yet with this classic story of Priam's son and the false Cressida (which Shakespeare also took for one of his plays), that we would have the young reader first taste of Chaucer's poetry. Rather begin with those exquisite little poems comprising "The Legend of Good Women," in which he relates the tragic love-stories of Cleopatra, Thisbe, Dido, Ariadne, and other classic heroines. These are each of a length sufficient to attract the reader who is not yet familiar with the poet's manner and to prepare him for the longer works.

It is a safe assertion that the reader who has borne Chaucer company through only two or three of these poems will require no counsel to cultivate acquaintance with the writings of this merry, wise and gentle poet, who was at once a scholar, a lover of books and ancient lore, but not the less a lusty Englishman, who rejoiced in the world out of doors and all the ways of Nature.

"And, as for me, though that my wit be lyte,
On bokes for to rede I me delyte,
And in myn herte have hem in reverence;
And to hem yeve swich lust and swich credence,
That ther is wel unethe game noon,
That from my bokes make me to goon,
But hit be other up-on the haly-day,
Or elles in the joly tyme of May;
Whan that I here the smale foules singe,
And that the floures ginne for to springe,
Farwell my studie, as lasting that sesoun!"

Chaucer's Life. Chaucer was the son of a London vintner, and is believed to have been born about the year 1340. He had the education of a gentleman, and has been claimed as a scholar of both Oxford and Cambridge, but there is no evidence of his having attended either university. He was a great favourite at the court of Edward III., and was a follower of John of Gaunt, "time-honoured Lancaster," to whom, by the poet's marriage with Philippa de Rouet, Chaucer later became brother-in-law. As a youth he had in France borne arms for Edward, and was for a time held prisoner of war. During a considerable part of his life he enjoyed prosperity, holding various official posts, and being, as we have heard, employed on diplomatic missions; but he experienced reverses of fortune during the early years of the reign of Richard II., and although he regained the favour of that monarch, as well as the regard of his successor, Henry IV., son of his patron, the Duke of Lancaster, the later period of his career seems to have been somewhat troubled. But this did not dim his genius, for his poetry was at its very best in the autumn of his days. He died in the year 1400, and his writings, which

had circulated in manuscript copies only during his own life, were first printed by Caxton, who issued an edition of "The Canterbury Tales" about the year 1475, while the earliest complete edition of his works was that by Godfrey in 1512.

So commanding is the figure of Geoffrey Chaucer in English mediæval literature that more than two hundred years have to pass before another stands beside him on the same plane, and even then it might be argued that it is a relation of master and disciple, for Spenser acknowledged Chaucer as his master. But they have really little in common, and there is more reason for believing Spenser's masters to have been the Italians, Ariosto and Tasso. Thus the poets who come between Chaucer and Spenser are not of any great account to the general reader, though several of them are eminently worthy of study by those who aim at a more intimate knowledge of our literature.

John Gower. Chaucer had in John Gower a fellow-poet and a friend who was only secondary in importance because it was his fate to live under the shadow cast by his great contemporary. Not that Gower had else been a great writer, for his limitations are so well defined that he is one of the authors over whom there is small reason for critics to disagree. He may be described as a man of great talent, ripe scholarship, character, but not a man of genius. While in sheer craftsmanship he was even Chaucer's superior, and perhaps in scholarship also, he lacked that divine fire which lifts the genius above considerations of craft. Gower wrote three large works, in French, Latin and English respectively. The first is no longer in existence, while the second, which is composed in Latin elegiac verse, describes the Wat Tyler rising, and thus has some value in the eyes of the historian, though it possesses none for the reader of poetry. His English work is his greatest, and has been reprinted in popular form within recent years, an edition being issued under the editorship of the late Professor Henry Morley. It is entitled "Confessio Amantis" (A Lover's Confession), and is most tedious reading. Its interest is mainly for the philologist, so it may very well be passed over by the general reader. Gower, who came of good family, died in 1408, and his effigy may still be seen on his tomb in St. Saviour's Church, Southwark, where he is shown with his head pillowed by his three ponderous works.

JOHN GOWER

John Barbour. Also contemporary with Chaucer and Gower was John Barbour, the first great Scottish poet, whose chief work, "The Bruce," is a national epic written in octosyllabic verse, remarkably spirited, full of movement, observation, and accepted by authorities as historically accurate; so that Barbour has the double value of historian and poet. The original is perhaps a little more difficult to read than Chaucer, whom Barbour resembles in his love of nature; but as the historical value of the work is at least equal to its poetical, there need be less hesitation in making its acquaintance in a modernised version. Most collections of Scottish poetry give considerable space to lengthy passages from "The Bruce." We may quote a few lines from the original to illustrate its style. They occur in the description of the launching of Bruce's galleys, with his little army of three hundred men, from the island of Arran, to cross the Firth of Clyde to Turnberry:

"This wes in Ver,[1] quhen wynter tyde,
With his blastis hidwyus[2] to byde
Was our drywyn,[3] and birdys smale,
As turturis[4] and the nychtyngale,
Begouth rycht sairely to syng,
And for to mak in thair singyng
Swete notis, and sownys ser,
And melodys pleasand to her."

Barbour, who was born in 1316, and died in 1375, was Archdeacon of Aberdeen for about forty years, and made several journeys through England and France, chiefly, it has been thought, to collect material for his books.

The Fifteenth Century. It is strange that after the splendid start which Chaucer had given to our literature, the fifteenth century should have been so barren of great writers, although in the latter part of that century Caxton introduced printing into the country. That English poets of the calibre of Thomas Occleve, who was thirty years old at the time of Chaucer's death; John Lydgate, a dull imitator of Chaucer; and Stephen Hawes, a writer of prolix allegories; and Henry the Minstrel, in Scotland, could achieve popularity, is sufficient proof of the poverty of the period in works of imagination. But King James I. of Scotland made good use of his long imprisonment in England by writing many poems, and notably "The King's Quhair" (Bo k), which are models of good English,

[1] Spring. [2] Bitter blasts. [3] Overpast. [4] Turtle-dove.

graceful in style, and at times approach close to Chaucer both in music and imagination. The student should read, in this connection, Washington Irving's fine essay, "A Royal Poet," in the "Sketch Book." Then JOHN SKELTON cuts no contemptible figure in fifteenth century literature, despite the adverse criticism to which he has always been subjected. "Beastly Skelton" is how Pope dismisses him, and Puttenham in his "Arte of English Poesie"—which, published in 1589, was one of the critical works that accompanied the Elizabethan literary revival—says of him: "Being indeed but a rude rayling rimer, and all his doings ridiculous; he used short distances and short measures, pleasing only the popular eare." But, all this notwithstanding, Skelton was our English Rabelais, with a good deal of the Frenchman's learning, his unrestrained delight in word-play, something of his satire, much of his coarseness and his joviality. Still, he is not for the average reader. Skelton, like WILLIAM DUNBAR, the Scots poet, who belongs equally to the fourteenth and fifteenth centuries, was also a priest; but Dunbar, on the whole, shows a better balanced character, and although he can rival his contemporary in coarseness when he cares —which is much too often—he displays public spirit in his satires, grace and wit in his allegories, and is at times capable of real pathos. Born about 1460-5, most of his life was spent at the Scottish court, and his most famous poem, "The Thrissill and the Rois" (The Thistle and the Rose), was an allegory on the marriage of James IV. with Margaret, eldest daughter of Henry VII. It is supposed that he accompanied the ambassadors who went to England to arrange the marriage. Dunbar died about 1522, in which year was born GAWIN DOUGLAS, Archbishop of Dunkeld, who wrote some animated poems, especially "The Palice of Honour," and rendered the "Æneid" into Lowland Scots, this being the first translation of a Latin classic published in Britain.

A Twilight of Genius. But unless we were to include Sir THOMAS MORE (b. 1480, d. 1535) among the poets who belong to the dim twilight of the Middle Age, though coming so near to the bright sunrise of the Elizabethan renaissance, there is hardly any name until we come to Sidney or Spenser that can be said to have much significance for the general reader. And More's "Utopia," written in Latin, though poetical in the quality of its imagination, is not so in form, so that it would be a deliberate straining of words to include him with the poets, especially as he must receive our consideration when we come to study the beginning of English prose. It is difficult to imagine him as the friend of JOHN HEYWOOD (b. 1506; d. 1565), a poor rhymer who is only interesting to the student as being one of the first to introduce into the drama subjects drawn from everyday life, and thus to hasten the end of the old "morality" plays. A writer more lacking in every literary grace it would be hard to find, and the fact that he was the favourite jester of Henry VIII. indicates the low standard of taste which prevailed at that time. Sir Thomas More and he may have been friends chiefly because they were both ardent Catholics. Sir Thomas Wyatt and his friend Henry, Earl of Surrey, were, however, poets whose works are worthy of passing attention, and who, as the originators of what we may call "amatory" verse in English, will always call for some notice. The ordinary reader may be content to make their acquaintance in anthologies, and will find as much of their verse as he need read in "The Surrey and Wyatt Anthology" (Oxford Press, 2*s.* 6*d.*).

Wyatt and Surrey. Sir THOMAS WYATT (b. 1503; d. 1542) wrote many graceful sonnets and lyrical poems characterised by a grave courtliness rather than the light touch of the true love-poet, while the EARL OF SURREY (b. 1517; d. 1547), though of a livelier temperament and a true lover, did not excel him in the quality of his verses. Wyatt introduced the sonnet stanza, Terza Rima, and blank verse into England from Italy, and these first two forms we shall illustrate further on. Surrey was the first of English poets to write any considerable poem in blank verse, into which he translated books II. and IV. of Virgil's "Æneid."

With Wyatt and Surrey, which latter the great French critic H. A. Taine, in his "History of English Literature," describes as "an English Petrarch," our language had at length acquired greater literary possibilities than it had before possessed: "Those who have ideas now possess an instrument capable of expressing them," says Taine, and to what purpose this instrument was used we shall proceed to inquire.

EXAMPLES OF ENGLISH METRES (see page 306).

1. *Trochaic.*
   Fōr thĕ ĕarth hĕ drēw ă strāight līne
2. *Iambic pentameter, blank verse.*
   Thĭs rōyăl thrōne ŏf kings, thĭs scēptĕr'd isle.
3. *The same, opening with trochee.*
   Măn ĭs ă shĭp thăt sāils wĭth ādvĕrse winds.
4. *Trochaic.*
   Hēnrȳ, tōō, hăth hēre hĭs pārt.
5. The line
   "Void of all succour and needful *com*fort" is wrong, because, the accent falling on the last syllable but one, there should be eleven syllables. It could be re-arranged thus:
   "Of succour and all needful comfort void," or made to scan by putting a second "of" before "needful."
6. *Dactylic.*
   Fārewĕll tŏ ōthĕrs, bŭt nēvĕr wĕ pārt.
7. *Anapæstic.*
   Lĭke thĕ lēāves ŏf thĕ fōrĕst whĕn sŭmmĕr ĭs grēēn.

To be continued

Continued from page 311

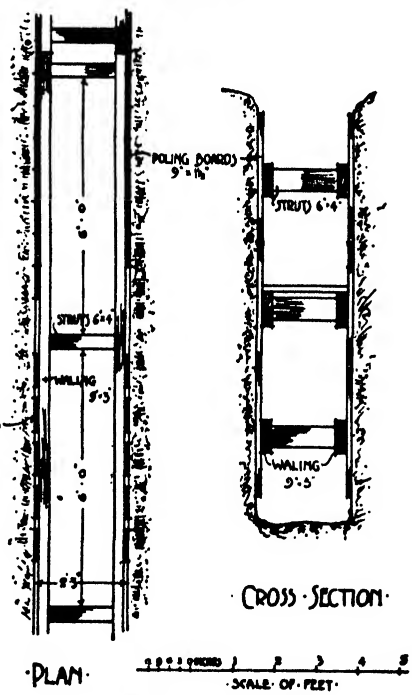
LAYING THE FOUNDATIONS

The Work of the Excavator. Soils and their Bearing Power. Natural and Artificial Foundations. Piling and Underpinning

By Professor R. ELSEY SMITH

Top Soil and General Levelling. In excavating a site it is usual first to remove any turf, setting it aside for relaying or sale. Turfs are usually three feet long, one foot wide, and are rolled. Gravel paths, flags, etc., may sometimes be similarly taken up and set aside. It is usual also to take up and set aside the top layer of earth if suitable for garden purposes. After this has been done the site must be levelled to the depths shown in the drawings.

In some cases a uniform level is required throughout. In other cases the level varies in different parts of the site. Hollows may require filling up, and in such cases the best of the material is selected for this purpose. The spoil, when excavated, increases considerably in bulk. Increase varies with different soils, but does not often exceed 20 per cent. Such material, if filled in again, gradually consolidates and contracts. To assist the process it is usual to water it liberally, and ram it. The settlement due to consolidation is usually not less than one inch in one foot, and may exceed this proportion considerably. Any material useful for building purposes — *e.g.* good gravel or sand free from loam or clay—may be put aside and used for building by arrangement with the owner.



4. TIMBERING TO A TRENCH

Trenches. When the general levels have been reached, any additional excavation for cellars, vaults, basements, etc., are made as well as trenches to receive the foundation and drains. Drain excavations are often deferred until the carcase of the building has been completed. All the excavations are sunk to the depths shown in the drawings. The trench required to take the concrete under a 9-inch brick wall is not less than 2 ft. 2 in. wide, just sufficient to allow a man to work in it; but he cannot throw out the spoil from beyond a depth of six feet, and if the excavation exceeds this, a stage must be provided on which he throws the spoil and from which it is thrown out, increasing the labour and the cost. An extra stage is required for every extra six feet in depth. In a ten-hours' day a good excavator can dig and throw into barrows eight to ten cubic yards of common ground, five to six cubic yards of stiff clay or firm gravel, and if hard ground, where the pick is used, three to five cubic yards. For deep drains tunnelling may have to be undertaken. This is done by sinking pits at convenient intervals and excavating short tunnels from one to the other. The width is determined by the nature of the work required. The height must be sufficient for a man to work in, and the sides are usually made to slope in towards the top of the tunnel.

In moist and wet soils water is liable to soak into excavations, especially in wet weather. All water must be got rid of by baling if the quantity is small, or by pumping if it is large. It should be constantly kept under, as it softens and deteriorates the surface of the trench.

Bearing Power of Soils. Trenches that have reached the depths shown upon the drawings should have the bottoms carefully tested to see that the stratum of soil is of a character suited to carry the load to be placed on it. In ordinary cases this may be done by driving in a crowbar to test the solidity of the ground, and on sites previously occupied an examination must be made for old and disused drains, wells, and cesspools, which, if built over, might collapse. Such drains or cesspools should be cleared away. Any old foundations should be grubbed up and cavities filled with concrete if walls or piers are to stand over them. Otherwise they should be filled with hard dry brick rubbish. Where the bearing capacity of the ground requires to be carefully tested, a strong platform with legs framed to it at the four corners may be used. If 6 in. by 6 in. legs are used, the area of the four together should equal one foot

superficial, and the table can be loaded with any convenient heavy material. The ground is carefully levelled and the table placed in position.

The level of each corner accurately taken in relation to some fixed datum, the load is applied gradually, evenly, and without shock; the levels are taken again from time to time, and the load is increased until variation is noticed. From one-fifth to one-half of the load required to produce settlement is taken as the safe load. If the load to be carried exceeds the safe load, a stronger stratum must be sought, or the weight per foot reduced by an increase of the area of the bearing surface.

TABLE OF BEARING POWER OF SOILS*

Material.	Bearing power in tons per square foot.	
	Min.	Max.
Rock, hard	25	30
„ soft	5	10
Clay in thick beds always dry	4	6
Clay in thick beds moderately dry ...	2	4
Clay, soft	1	2
Gravel and coarse sand well cemented	8	10
Sand, compact and well cemented ...	4	6
„ clean and dry	2	4
Quicksand, alluvial soils	½	1

Small sections of soft ground are sometimes found in trenches otherwise satisfactory. These may often be dug out to a sound bottom and filled with concrete without deepening the whole trench. On a sloping site it may be necessary to introduce steps into the trenches, but in all cases the bottom of the trench for foundations should be kept level; those for drains may be excavated to conform to the fall in the drain.

The concrete should be laid in the trench as soon as possible after opening to protect the foundation from the weather.

Timbering. Where it is necessary to carry excavations perpendicularly or nearly so, as in trenches or for cellars, means must be taken to support temporarily the face of the earth which is liable to crumble away or be forced into the trench. In some shallow excavations this precaution is not necessary if the trench is to be open for a short time only, but in loose soils even shallow trenches, and in all soils deep trenches, must be protected. This is done by *timbering*.

The nature of the work depends on the character of the soil. Good soils are usually natural or *virgin* soils that have not been disturbed and include dry clay. Moderate soils include ground that has been filled in (termed *made ground*), loose gravel, while treacherous soils include sand, wet clay, all water-logged soils, and even ordinarily good soils if trenches are dug near existing excavations.

The materials used for timbering are *poling boards*—*i.e.* short lengths of board usually 9 in. by 1½ in. and 3 ft. long, but sometimes longer, placed vertically against the sides; *waling pieces*, which are horizontal timbers usually 9 in. by 3 in., placed about the centre of the poling boards, and *struts* to keep the whole in position.

Methods in Different Soils. In good soils continuous timbering may not be required if the trench is not very deep or wide. In such cases a pair of poling boards are placed against each face of the excavation opposite each other. The strut is cut about half an inch or three-quarters of an inch longer than the distance between the boards inserted between them and forced into a horizontal position with the help of a heavy hammer. Pairs of boards thus fixed may be placed at intervals of about six feet. If placed closer they impede the excavator in his digging, and if they do not suffice to keep the sides intact, a different system must be adopted. The poling boards are then placed with only short intervals between them, or in some soils actually touching. Strong horizontal timbers termed *waling pieces* are placed in front of them at about the centre of the height and secured with struts, as already described. In a long trench the waling pieces have to be joined and a strut is placed close to the end of each length [4], with intermediate ones at intervals of six feet. Such timbering is put into position and secured as soon as the trench is of sufficient depth—about three feet—and before any further ground is excavated. As the digging proceeds in deep trenches, similar timbering is placed below the first in successive stages as required, care being taken to keep the struts vertically below those above.

In some soils the vertical face cannot be relied upon to stand safely even while a three foot trench is being dug. In such cases, in place of vertical poling boards, horizontal planks (termed sheetings) are placed in position as soon as from nine inches to twelve inches in depth has been excavated and temporarily strutted. Then, when another layer is removed, a second board is placed below the first and strutted, and so on, until a depth of about three feet has been reached. Vertical walings are then placed in front of the boards and secured with struts, the temporary ones being afterwards removed. A greater depth may then be got out and protected in the same way. The platforms or stages required in deep trenches for throwing out the spoil may be carried on the waling pieces.

Water-logged Ground. In water-logged ground special precautions must be taken, and heavy and very sound timber used. Longer boards, usually 11 in. by 3 in. and up to eight feet long, are used in place of poling boards, and are termed *runners* [5]. The feet are cut to an inclined chisel edge and in strong ground shod with iron, as in sheet piling. In fixing after ground is excavated as far as is safe, guide runners, about ten feet apart, are driven in by mallets and strong waling pieces fixed and strutted. Other runners are inserted and driven in until a continuous wall is formed. Excavation then proceeds until within about a foot of the bottom of the runners, when they are driven further down, additional walings inserted, and the struts increased with the depth.

In a deep trench, if a second set of runners (or

* Ira O. Baker, C.E., in "Treatise on Masonry Construction."

more) is required, they are not set under the upper ones, but within them, so that the width of the trench is narrowed, and allowance for this must be made in setting out the upper trench. The heads of the lower runners must not be driven deeper than about 12 inches above the feet of the upper runners.

Tunnelling. Where tunnelling is employed similar precautions must be taken. A shaft is sunk to the required depth, the tunnel is worked in from the face, a commencement is made at the head, and as soon as the roof shows any signs of insecurity poling boards are driven in close against the roof and supported by a cross-beam or *header*, the ends of which are strutted from the floor, the feet of the struts being let into it to prevent accidental disturbance

Poling boards can be driven in behind the struts [6]. Excavation then continues until another set of poling boards and frame can be inserted. In very bad or wet soil a more elaborate plan is necessary. The poling boards are longer and directly supported by squared timbers arranged as a frame. These in turn are supported by horizontal pieces which are themselves strutted by a very strong frame, often including a sill to take the feet of the struts, which must be sunk below the floor level. Notches are cut in the heads and sills and the struts fitted to them, but large spikes are sometimes used for increased security.

Large excavations also require to have the sides timbered; the system is generally similar, but the walings are usually heavier, and the struts are formed of large timbers and are tightened with folding wedges [7]. In excavations too wide for strutting the walings require to be supported by shores [see SHORING] placed at intervals along the sides of the excavation.

Natural Foundations. The natural soil on which a building rests has to bear the whole burden of the superstructure, which must be disposed so as not to cast too heavy a load on any part of it. Every wall is required by the London Building Act and by most Local Acts to have footings [see BRICKLAYING] equal in width to twice the thickness of the wall, and in addition, with a few exceptions, to have a slab of concrete under it at least eight inches wider than the footings. For fairly good soils and with ordinary buildings of moderate height this secures a sufficient distribution of the load for security.

In the case of buildings in which different parts are unequally loaded and where heavy loads are carried by detached piers or stanchions, it is important not only that the load should not exceed the bearing capacity of the soil, but that the pressure upon it should be as nearly as possible equal at all points; so that should any settlement occur in the foundations, it will be uniform, otherwise the more heavily laden parts will be the most liable to sink, producing cracks in the superstructure.

It is therefore necessary to calculate the actual weight of materials supported by each square foot of brick or stone in the general walls, as well as in the piers and to regulate the area of the concrete under them so as to produce a uniform pressure. In this calculation must be included the proportion of every floor area and of the roof carried by the wall or pier, including the load it is intended to carry.

For domestic buildings an allowance of 1 cwt. per foot super of floor, including the load, is an ample allowance, though 1¼ cwt. is often allowed. For public buildings 1½ cwt. per foot super, including the load, is allowed. For warehouses and other special buildings it is necessary to ascertain the actual load to be carried, which is often from 2 cwt. to 3 cwt., and may be as high as 6 cwt. per foot super.

Rock. Of the various soils usually met with in foundations, the strongest is *rock*. This will support any load that is likely to be put upon it, even if not a strong rock, and makes an excellent foundation if it entirely covers the site. Many rocks are apt to hold water in pockets and fissures, and means must be taken to get rid of this by giving the surface a slight inclination and arranging for the discharge of any water that collects.

Any loose or decayed material on the surface must be cleared off, and if the surface is not level the stone must be worked into level beds under the footings and stepped where necessary. Holes and fissures may be levelled up with cement concrete, or, if large and deep, may be arched over in stone or concrete unless they come directly under a heavily loaded pier. Should the rock only extend over part of the site, the remainder being of some less solid material, the foundation is by no means easy to deal with, and great care must be exercised to give a sufficient bearing to the portions of the building on the weaker soil, or an unequal settlement may develop.

Clay. Clay varies greatly, according to its nature and position. The blue London clay forms a first-rate foundation, but is only encountered as a rule at considerable depths. The ordinary yellow clay varies greatly. It will sustain any reasonable load if fairly dry and not subjected to influences that will change its condition. It is essential to carry down excavations below the level at which it is affected by changes of weather and climate, and for safety this may usually be taken at about five feet below the surface. Clay that is liable to be reached by an excess of water becomes soft and plastic, and will squeeze out under pressure, and trenches in clay in particular should be concreted as quickly as possible. There is the further liability on sloping ground that excavations may be opened at a lower level, drain the moisture from the subsoil and so produce subsidence, and in consequence of its liability to change with altering circumstances, the yellow clay should be looked upon as a foundation requiring very cautious handling.

Gravel. Gravel is one of the best foundations after rock. If compact, and where an entire foundation consists of this material, footings may be constructed on it without concrete beneath them. The gravel must not, however, be in a position where it is subject to

erosion by flowing water, or it must be properly protected from such action. Even loose gravel, if confined so that it cannot spread, forms a good basis for building, but a slab of concrete should be used.

Sand. Sand also makes a good foundation if it is confined so that it cannot spread and is protected from erosion. It is practically incompressible, but is easily washed away by running water. If the bottoms of the trenches require to be stepped or if a deeper excavation for cellars is required, care must be taken to prevent the sand in the upper parts from being forced out.

Chalk. Chalk varies considerably in quality and is liable to disintegrate if exposed to the action of the weather. The strata immediately below the top soil are often somewhat loose, but if excavations are carried below the weather line a very good sound foundation is usually reached. There are apt to be fissures and pockets of loose gravel and sand, which if they come under walls or piers should be emptied and filled with concrete, or, if the load is light, they may be covered with a thick slab of concrete. An exposed chalk face should be protected from the action of the weather by a facing of brickwork, stone, or flint.

Quicksand, Alluvial Soils, and Made Ground. Quicksand, alluvial soils, and made ground are all unsatisfactory as foundations. They are compressible, and made ground in particular is liable to contain putrescible material. Circumstances may arise in which buildings must be erected on such foundations, and in all such cases special precautions must be taken. The circumstances of each individual case must be carefully considered as it arises.

Made ground varies much in character. It may be the result of excavations for sand or gravel, which have been replaced by other hard dry material, which, with the lapse of years, attains very fair solidity, or it may be the result of a general raising of the level of a low-lying locality, such as has taken place in parts of the East of London. In the latter case, road sweepings, ashes, etc., are often employed, sometimes in a wet condition, when they will be offensive for a long time, and will never become well solidified. The presence of putrescible matter in the soil may be a source of danger to health, as the ground air under some conditions is drawn into buildings by the action of ordinary fireplaces.

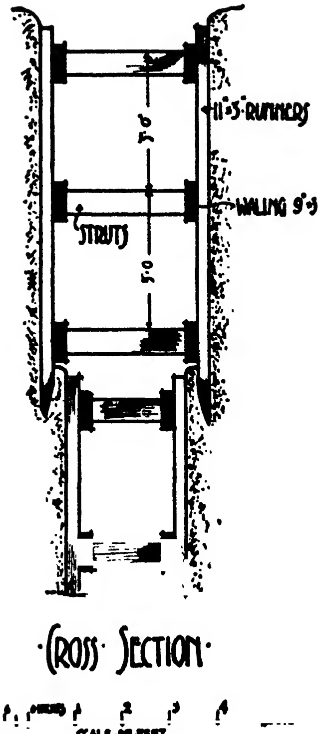
Trial Holes. Before the building is designed, the nature of the soil, unless well known, must be ascertained by sinking square pits or trial holes at various parts of the site, noting the character of the strata pierced and seeing whether their character varies in the different pits. Where a soft stratum occurs above a hard one, it is as a rule desirable to sink the foundations to the harder bed, but where a hard stratum occurs above a soft one, it is often safe to build on the upper one, provided it is possible to leave a considerable thickness of it undisturbed. In such cases much will depend upon the building to be erected, and inquiry as to the circumstances of surrounding buildings must be made and judgment exercised. No hard-and-fast rule can be laid down. A thorough acquaintance with the nature and capabilities of the bearing stratum is not only necessary before the work is started, but should, when heavy loads have to be dealt with, be gained before the footings are designed.

Artificial Foundations. The footings of a wall or pier can seldom be laid on the natural foundation. Almost always some other provision must be made to receive them, and this must vary with the nature of the natural foundation and the load it has to bear. The loads to be carried due to walls and piers respectively having been calculated, the safe load that the natural foundation will sustain and the area of the bearing surface under each may be ascertained and the trenches excavated to the required size. With a good natural foundation, even when heavy loads are to be carried, a thick layer of concrete is the material usually employed. With poor and treacherous soils other methods must be adopted.

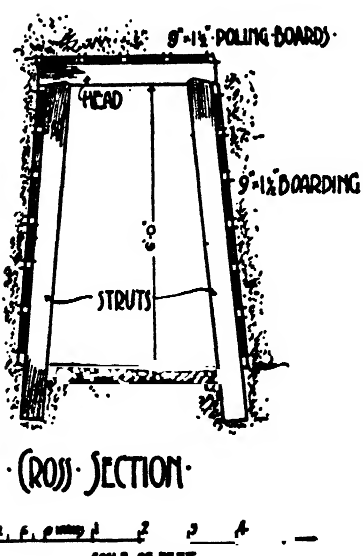
Concrete. Concrete is a material which, when first formed, is in a plastic condition, and can be filled into any prepared excavation or mould. Within a few hours it sets into a solid rock-like mass, and within a few days attains a very considerable strength, though its maximum strength is not reached for months. It is composed of some hard substance broken into small pieces termed the *aggregate*, forming the bulk of it, and of a binding material termed the *matrix*. The nature of the *aggregate* varies according to the purpose for which the concrete is to be used. For foundation work and walls nothing better can be had than stone ballast from a river or pit gravel. Shingle for many purposes is suitable, but the stones in it are not "sharp" or angular, as is desirable, and the presence of salt renders the concrete liable to show signs of damp in wet weather or in moist situations. Other substances used are broken stone, clinker, burnt ballast (only permissible if thoroughly vitrified), and broken brick and pottery, which must also be thoroughly burnt. Underburnt bricks or ballast are not suitable. An excellent concrete results from about 25 per cent. of good broken brick with some form of stone aggregate. Whatever the material, it must be broken up to pass some standard. A two-inch ring is very often specified. This secures a solid uniform material without cavities.

Concrete Floors. For concrete floors laid on the solid, similar aggregates may be used. For upper floors, roofs, etc., in fire-resisting structures, lightness is of importance. Coke-breeze and pumice-stone are often employed, and for such purposes should be broken fine enough to pass through a one-inch ring. This is termed fine concrete. For concrete stairs, pavings, etc., the aggregate consists largely of granite chippings.

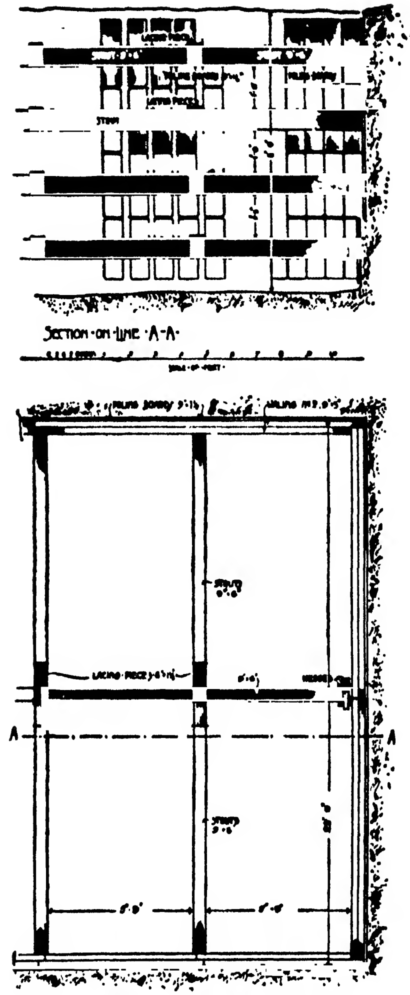
If the aggregate does not contain sand, sand or some substitute must be added to the extent of about 25 per cent. to 30 per cent. of the total bulk. The object of the sand is to fill up all interstices and to give cohesion. It is essential that the aggregate should be clean, free from all animal and vegetable impurities, and



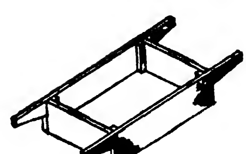
5. TIMBERING TO A TRENCH IN BAD SOIL



6. TIMBERING FOR A TUNNEL

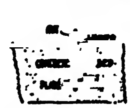


7. EXAMPLE OF TIMBERING FOR A LARGE EXCAVATION

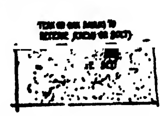


8. GAUGE-BOX FOR CONCRETE-MIXING

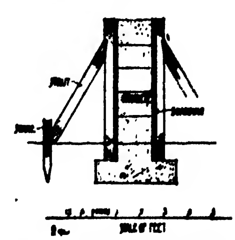
9. PLAN OF VERTICAL CONCRETE JOINT



10. HOLDING-DOWN BOLT IN CONCRETE



11. BEAMS IMBEDDED IN CONCRETE



12. METHOD OF FORMING CONCRETE WALL

ILLUSTRATIONS OF PROCESSES IN EXCAVATING AND CONCRETE WORK

that the sand should be sharp and free from loam. If loam be present, the sand must be washed. Washing is done in a tub of water. A large circular sieve is used, and with the sand is dipped into water till submerged. It is rotated so that the loam is washed out, and the sand is then thrown out into a heap.

The Matrix. The matrix consists of hydraulic lime or Portland cement [see MATERIALS AND STRUCTURES]. The proportion of matrix to aggregate varies with the nature of the matrix, with the situation of the concrete, and the work it has to do. In the case of lime, if only feebly hydraulic, the proportion should not exceed one of lime to four or five of aggregate. Such concrete is not suitable for use in very large masses or in moist situations. If eminently hydraulic it may be one of lime to seven of aggregate. With cement the proportion may be one of cement to eight or nine of aggregate for concrete walling, and one of cement to five or six of aggregate for wet foundations and for concrete flooring.

Water. The water used must be clean, and it is important that no more should be employed than is necessary for the proper mixing of the ingredients. An excess of water reduces the ultimate strength of the concrete. The method of mixing is as follows: The proportion of matrix and aggregate being fixed by the specification, square frames without tops or bottoms are made [8]; the smaller contains a single unit, say a yard, for the matrix, the larger the corresponding number of units required for the aggregate. If the aggregate is not formed with a single material, but has, *e.g.*, a certain proportion of brick mixed with it, this is most usually incorporated before the mixing of concrete itself begins, but if necessary three or more frames may be employed, each proportioned in capacity to the amount of material to be used.

A close-boarded floor is provided as close to the spot where the concrete is to be used as possible, or a floor of sheet iron is sometimes used. The frames are placed on it, filled up level to the top (but not heaped up), and then removed. The aggregate is spread out, the matrix spread evenly over it, and the two thoroughly mixed by being twice turned over with shovels, dry—*i.e.* without any water. They are finally turned over with the addition of the necessary water, forming concrete, which is at once conveyed to the spot where it is to be deposited. In the case of trenches for foundation work, it may sometimes be thrown in by shovels direct. More usually it is filled into barrows, wheeled and tipped in. This must not be done from any great height, or the larger stones will collect at the bottom and the mass not be homogeneous.

Depth. If the depth of concrete is not great, say, 12 in. to 18 in., the full depth may be at once placed in the trench, in which stakes are driven and carefully levelled, marking the top of the concrete, which is spread and levelled by a labourer standing in the trench as soon as it is deposited, and should not afterwards be disturbed. Where a deep bed of concrete is required, it is usual to deposit it in successive layers of about 12 in. at a time. In the case of deep trenches the concrete must be lowered in bags or in barrows to a stage from which it can be tipped. Concrete should not be deposited in trenches containing water, which is apt to wash out the cement, leaving the lower part of the concrete poor. Water, however, does not interfere with the setting of concrete mixed with eminently hydraulic lime or cement. If used under water, it must be lowered in sacks and the surface protected till setting occurs.

Where a horizontal bed cannot be completed without interruption, it is usual to form the end with a V-shaped recess on plan [9] to give a vertical key to the next layer of concrete, and if this is not put in till the first is dry, the joint should be well wetted before the new concrete is deposited. Where successive layers are used, care must be taken that no mould from the trench or dust or rubbish is left on the upper surface of the old bed before the new concrete is deposited. The top surface of the final layer is levelled and smoothed over to receive the brick footings.

Concrete over Site. The concrete which is usually spread over the whole site within the walls, and which may form the bed for solid floors, or may be some distance below boarded floors, is usually cement concrete not less than six inches thick, spread uniformly, and with the upper surface smoothed over with a spade or shovel. Upper floors are filled in on a centre. This may be a close-boarded, flat, wooden centre [see CENTREING], or may consist of terra cotta lintels, iron sheets, etc., which remain as part of the floor. When concrete is used in this way in combination with iron or steel joists, it must be well rammed around the flanges.

Concrete may also be filled into moulds, and when set used as blocks for building or as lintels, channels, etc. Concrete walling may also be cast in position. In this construction the space to be occupied by the wall is enclosed with close boarding fixed to upright posts, well tied and strutted, and the concrete is filled in in layers of about twelve inches at a time [12]. This is often done for retaining walls, but buildings of concrete have even been constructed in this manner.

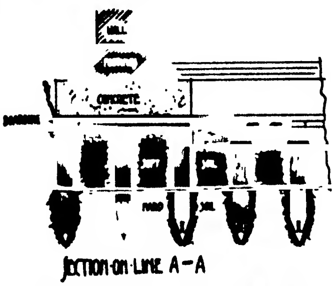
In the case of concrete masses intended to receive heavy machinery provision must be made for securing the machinery. This may be done by building in iron or steel girders, to which they are bolted, or by building in holding-down bolts with anchor plates [10], and in all such cases templates giving exact position of bolts must be obtained from the firm supplying the machinery. Pieces of timber dovetailed in section are sometimes built into concrete beds standing above the surface of the concrete for lighter machinery [11], and are useful where machines must be shifted [see also FIRE AND FERRO-CONCRETE].

Foundations on Compressible Soils. Such foundations, even for heavy buildings, are sometimes inevitable, and in such cases means must be taken to render the natural foundation capable of supporting the superincumbent load. The circumstances are so varied that we cannot deal exhaustively with every

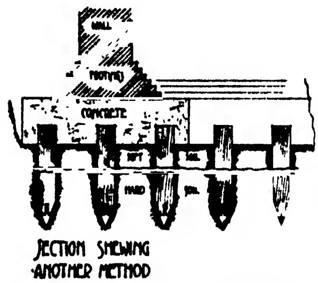
case, but must refer to the general methods of dealing with this difficult problem. Such foundations are inevitably costly, but the cost must be faced.

The method will depend upon the nature of the site. If the compressible stratum overlies a good solid stratum, but the latter is so deep that the cost of taking down the walls of the building is prohibitive, it may nevertheless be possible to take down piers of concrete or masonry to the lower level at short intervals and to throw arches or girders from pier to pier to carry the walls. This is only possible when the soft stratum is of a character that will permit of shafts being sunk, and cannot be employed for anything in the nature of quicksand or water-logged strata.

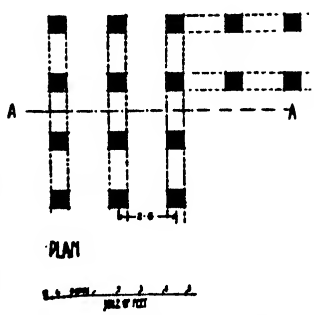
The area of such piers must be proportioned to the loads to be carried. The bottom must be carried well into the solid stratum and the piers carefully constructed. Their spacing must depend upon the nature of the building to be supported, but they will not be, as a rule, more than ten feet apart in the clear. Iron screw-piles may sometimes be employed in such circumstances spaced at greater intervals and the tops connected by heavy girders. [For description of screw-piles see CIVIL ENGINEERING.]



13. PILING WITH TIMBER PLATFORM



14. PILING WITH CONCRETE PLATFORM



15. PLAN OF PILES UNDER A WALL AND CROSS-WALL

Piling. When the soft stratum is very deep or very treacherous, say 30 ft. or 40 ft., the system of piers is not suitable, and in such cases long piles may be driven through the treacherous ground into the solid stratum below. [For piles and pile-driving see CIVIL ENGINEERING.] In America, where buildings of great height are erected, it is frequently the custom to drive in piles two to three feet apart centre to centre in rows spaced at intervals of about 2 ft. 6 in. centre to centre over the entire surface of the site. In most cases it may suffice to drive two or three rows of piles under the lines of the main walls [15]. Care must be taken to cut off the tops at such a level as to be below that at which water stands, for if the tops are dry, they will decay.

The piles may be capped with granite blocks, each of which rests on two or three piles, but not on more, owing to the difficulty of securing even bearing. The footings are started above the granite. Another method is to excavate the ground for a depth of 12 inches between the piles, to fill in between them with good cement concrete in layers, and to raise the concrete about 18 inches above the level of the pile head [14]. The concrete filling up to the level of the heads may be usefully employed under granite capping.

A third method is to connect the heads of the piles with heavy timbers, say 12 in. by 12 in., secured with bolts to the piles and running in the direction of the rows, and upon these to lay strong transverse timbers to receive the concrete [13]. In this case all such timbers must be kept below the water level. In the case of foundations which are liable to spread—such as sand with water—but which if confined will carry considerable loads, the whole area of the site may be surrounded with sheet piling and the site covered with a thick bed of concrete. When the depth of the soft ground is so great that solid ground cannot be reached, piling may still be resorted to, but in this case the piles will depend solely on the friction between the sides and the surrounding earth, and will not carry so great a load as if driven to the solid, and will generally require to be about 40 feet long. Other methods are to use very deep beds of concrete under the walls, which by their weight will compress and solidify the ground.

Underpinning. Underpinning, which consists in carrying down an existing wall to a greater depth and providing it with a new foundation without disturbing the superstructure, is often necessary. If the superstructure is heavy, it must be *shored* and perhaps *needled*, but with light structures, if the wall is thoroughly sound, this is not always necessary.

The old footings and cement must usually be cut away, the excavation to receive the new work carried down in short sections at a time, not more than three or four feet in length [see BRICKLAYER]. When the first series of excavations have been made and the work set, the intermediate pieces are dealt with. Great care is required to see that the concrete surfaces between the successive blocks are clean and a good junction is made. The brickwork is toothed all the way up.

To be continued

A SHORT DICTIONARY OF TERMS USED IN BUILDING

COMPRISING EXCAVATING, TIMBERING, SHORING, DRAIN LAYING, ETC.

AGRICULTURAL DRAIN—A drain conveying surface water from land.
Asphalte—A natural bituminous substance impervious to water.

BALLAST—Sandy gravel dredged from river beds used for concrete.
Ballast, burnt—Clay dug from excavations and burnt in its natural state.
Barrel drain—One in the form of a hollow cylinder.
Bends—Channels or pipes curved on plan.

CEMENT—A material used for binding together other material and capable of setting without the access of air.
Cement concrete, and mortar—Concrete or mortar the matrix of which consists of cement.
Centre—Temporary frame of wood on which an arch or vault is constructed.
Cesspool—A well formed below the ground to receive sewage.
Chair—Support used in drain laying to raise pipes above concrete bed.
Channel pipe—Pipe of half round section.
Clamp—Rectangular mass of crude bricks stacked for burning.
Clay puddle—Clay tempered with water.
Cleaning eye—An opening in a pipe through which it may be cleansed.
Cleat—Block of timber fixed to any timber to support a strut.
Clinker—A small vitrified brick used for paving.
Coffer dam—A temporary water-tight wall of timber and clay puddle to keep out water during building operations close by.
Concrete—A compound formed of various hard dry materials mixed with lime or cement and water which sets into a solid mass.
Crane—Machine for raising and shifting heavy weights.

DEAD SHORE—Vertical shore carrying a dead load.
Derrick—Form of crane often raised to and used at a great height from the ground.
Derrick stage—Form of gantry to support an elevated derrick.
Disconnecting chamber—Chamber formed in the length of a drain in which the house drain is disconnected from a sewer.
Dog-iron—Iron bar with ends sharpened and bent to right angles for holding together heavy timbers.
Drain—Pipe for the conveyance of sewage and waste water.
Drain-pipes—Cylindrical tubes used to form a drain.

EXCAVATION—A trench, pit, or tunnel dug out below the level of the ground.
Excavator—Labourer who digs and removes earth, etc., to level sites or form trenches, pits, and tunnels.

FENDER—Balk of timber placed outside a gantry to keep carts from damaging the uprights.
Flat centring—Temporary frame of wood on which a flat concrete floor is formed.
Flushing tank—Chamber filled with water and discharged at intervals to cleanse drains.
Flying shore—One placed horizontally across an open space between two buildings.
Fresh air inlet (abbreviation F.A.I.)—Inlet into disconnecting chamber of a drain to admit ventilation.

GANTRY—Temporary erection of squared timbers for dealing with heavy loads.
Granolithic—Species of fine concrete formed with granite chips used for paving and steps.
Gravel—Natural soil composed of small stones and sand.
Grease-trap—Form of trap to receive the discharge from a scullery sink.
Grub up—To break up and clear old foundations, drains, roots, &c., from a site.
Gully—Form of trap to receive waste water from ground surfaces or pipes.

HARD CORE—Hard dry broken rubbish.
Head—In gantries the beam carried by the uprights.
Hoggin—Screenings from pit gravel used for covering paths.
Holdfast—Iron spike with flat head for driving into brickwork.
Hoop-iron—Long flat strips of iron of various widths and gauges.
Horsing—Term used for strutting up centring from a solid base.
Hydraulicity—Capacity of cements and some limes to set without exposure to the air when mixed into a paste with water.

INSPECTION EYE—Opening in a drain or pipe by which it may be examined.
Invert—Lower part of a drain-pipe or sewer.

JUNCTION—Drain-pipe with side inlet for another pipe.
Junction block—Block built into sewer with inlet for drain-pipe.

LAGGINGS—Strips of wood nailed to centres to carry wide arches and vaults.
Lamp hole—Aperture for lowering a light into a drain.
Ledger—In scaffolding the horizontal timber carrying putlogs.
Lime—Material produced by calcining limestones.
Limekiln—Structures in which lime is calcined.
Loam—Soil in which clay prevails.

MADE GROUND—Ground which has been filled in, not virgin soil.
Main drain—Principal drain with which branch drains are connected.
Manhole—Chamber formed in the length of a drain for cleansing and to receive branch drains.
Metalling—Hard material forming the wearing surface of a road.
Monkey—Moving weight used in a pile engine for driving piles.

NEAT CEMENT—Cement used without sand.
Needle—In shoring a timber passed through a wall the ends of which are supported. Also the small timber inserted through wall-piece to receive head of raking shore.

PILES—Long timbers driven into loose ground to support superstructure.
Pile engine—Apparatus for driving in piles.
Plaster of Paris—Material produced by calcining gypsum (*selenite*).
Poling boards—Short boards used in timbering foundations.
Portland cement—Artificial cement of great strength and eminently hydraulic.
Pumice—A light volcanic stone.
Putlogs—Short square timbers used in scaffolding to carry scaffold boards.
Putlog holes—Holes left in brick walls to receive the inner end of putlogs.

QUICKLIME—Material produced by calcining pure limestone.

RAKING SHORE—One making an inclination with the horizon.
Retaining wall—One built to uphold a bank of earth.
Riding shore—One not carried down to the ground, but rising from the back of a raking shore.

SAND—Fine very hard material procured from pits, river beds, and the seashore, may also be crushed from sandstone.
Scaffold—Temporary erection from which permanent walls are constructed.
Scaffold boards—Stout boards with ends bound with hoop-iron, used to form platforms on a scaffold.
Scaffolder—Superior labourer specially engaged in erecting and altering scaffolds.
Scaffold height—Distance between successive ledgers in a scaffold, usually five feet.
Screw pile—Hollow cylindrical iron pile with large projecting screw at its base.
Selenitic lime or cement—One containing a small proportion of sulphate of lime, as plaster of Paris.
Setting—Hardening of a lime or cement mixed into a paste with water.
Sewer—Drain usually under public road to receive drainage of several buildings.
Shoring—The system of propping or strutting a building temporarily with timbers.
Silt—Muddy deposit from rivers.
Slaking—Chemical combination of quicklime with water.
Sleeper—In a gantry the horizontal beam on which the uprights stand.
Socket-pipe—One having socket formed at one end to receive end of next pipe.
Solepiece—Timber on which a system of shores rests.
Spigot end—End of a pipe that fits into socket.
Spoil—Material that has been excavated.
Standards—Vertical posts of a scaffold.
Steening—Brick lining without mortar in a cylindrical well or cesspool.

TAPER PIPE—One of which the diameter is regularly reduced from end to end.
Tar paving—Mixture of tar and shingle used to pave footpaths and areas.
Three-quarter pipe—Pipe of which three quarters of the circumference is formed.
Trap—In drainage a device to prevent the admission of sewer gas into a building while allowing sewage to pass through it.
Traveller—Small crane mounted on rails and able to move to and fro.
Trench—Excavation with parallel sides for the base of a wall or for a drain.
Turning piece—A small centre cut from a thick board on which arches with narrow soffits are constructed.

UPRIGHT—Vertical timbers of a gantry.

WALINGS—Horizontal timbers used in connection with piling and in timbering excavations.
Wall piece—In shoring, a wood plate placed vertically against the wall.
Water seal—Depth to which the upper part of a trap extends below the water standing in it.

FACTORS AND NUMBERS

The Metric System; Factors and Prime Numbers; Highest Common Factor and Least Common Multiple, with Problems

By HERBERT J. ALLPORT

THE METRIC SYSTEM

49. In most European countries the *Metre* is the unit of Length. This is the fundamental unit of the Metric System; the units of weight, area, and capacity all being derived from it.

The Metre was originally defined as being one ten-millionth of the calculated distance from the equator to the north pole, measured on the meridian of Paris. Its equivalent in English measure is approximately 39·37 inches.

The metre is divided into 10 equal parts, called *decimetres*; the decimetre into 10 equal parts, called *centimetres*; and the centimetre into 10 equal parts, called *millimetres*.

Similarly—10 metres = 1 *decametre*,
10 decametres = 1 *hectometre*,
10 hectometres = 1 *kilometre*,
10 kilometres = 1 *myriametre*.

Thus, Greek prefixes, *Deca-*, *Hecto-*, etc., indicate units greater than the metre, and Latin prefixes indicate units less than the metre.

The abbreviations for Decametre, etc., are Dm., Hm., Km., Mm.; and for decimetre, etc., are dm., cm., mm.

50. Since the system is a *decimal* system (*i.e.* based on the number 10) the *notation* will be exactly the same as that in Art. 29.

Thus, 8 Dm. 5 m. 7 dm. 4 mm. will be written 85·704 metres.

The process of Reduction consists of no more than an alteration in the position of the decimal point.

For example, 85·704 metret is equal to 857·04 dm., or 8570·4 cm., or 8·5704 Dm., or ·085704 Km., etc.

Addition, subtraction, multiplication, and division, are done just as in Arts. 30–33.

Example 1. Add together, and express in metres, 4128 cm., 5926 mm., 782 dm., 519 cm., 2900 mm.

41·28 5·926 78·2 5·19 2·9 133·496 metres *Ans.*	Express each quantity in metres, by moving the point. Write the points under one another, and proceed as in Art. 30.

Example 2. How many times can 5 dm. 2 cm. 7 mm. be subtracted from 6 m. 3 dm. 2 cm. 4 mm.?

Here, required no. =

$$\frac{6\text{ m. }3\text{ dm. }2\text{ cm. }4\text{ mm.}}{5\text{ dm. }2\text{ cm. }7\text{ mm.}} = \frac{6324\text{ mm.}}{527\text{ mm.}} = 12\text{ times } \textit{Ans.}$$

51. The unit of Surface is the Square Metre. The table is—

100 sq. mm. = 1 sq. cm.
100 sq. cm = 1 sq. dm.
100 sq. dm. = 1 sq. m.
100 sq. m. = 1 sq. Dm.
etc.

The Are = 100 sq. metres. Its multiples are the decare, hectare, etc., and its divisions the deciare, centiare, etc.

The unit of Volume is the Cubic Metre.
The table is—

1000 cu. mm. = 1 cu. cm.
1000 cu. cm. = 1 cu. dm.
1000 cu. dm. = 1 cu. m.
etc.

The unit of Capacity is the Litre, and is equal to the content of a cubic decimetre. (English equivalent = $1\frac{3}{4}$ pints, approx.) Hence, we have centilitre, decilitre, etc.

The unit of Weight is the Gramme, or Gram, and is equal to the weight of 1 cubic cm. of distilled water at a temperature of 4° Centigrade Hence, kilogramme, hectogramme, etc.

1 quintal = 100 kilogrammes.

52. The French system of Money is also connected with the metre: the *franc* being a silver coin weighing 5 grammes. 1 franc = 100 centimes.

EXAMPLES 8

1. Write in litres and add together, 179486 dl., 2951 Dl., 307 l., 54 Hl., 729825 ml.
2. Write in sq. metres, and add together, 12345 sq. cm., 43 sq. Dm., 3529 sq. m., 7146 sq. dm.
3. Writes in ares, and add together, 42 sq. decametres, 6240 sq. metres, 275 deciares, 42 hectares.
4. Multiply 24 grams, 5 dg. 4 mg. by 63. Give the answer in cgs.
5. How many times can 47 mm. be taken from 90 Hm. 7 Dm. 2 m. 3 dm. 5 cm.? Express the remainder in metres.
6. Find the value in francs of 124 Kg. 3 Hg. 5 g. of salt, at 25 centimes per Kg.
7. What will be the cost of 2 Hl. 7 Dl. 5 l. of wine, at 3 francs 50 centimes per litre?
8. How many sheets of cardboard 1·5 mm. thick are there in a pile 2·7 metres high?
9. Assuming 8 kilometres = 5 miles, how many minutes shall I take to walk 1 kilometre, if I walk at the rate of 4 miles per hour?

FACTORS

53. We have seen (Art. 15) that when two or more numbers are multiplied together, the result is called the *product* of the numbers, and each of the numbers is called a *factor* of the product.

A *prime number* is a number which has no factors (except itself and unity).

Any other number is called a *composite* number. The *prime factors* of a composite number are the prime numbers whose product is the composite number.

Example. *The prime factors of 60 are 2, 2, 3, 5. For 2, 2, 3, 5 are all prime numbers, and their product is 60.*

Two numbers are said to be *prime to one another* when there is no number except unity which will divide both of them exactly.

Example. 18 and 35 are prime to one another, since no number will divide both 18 and 35 and leave no remainder in either case.

Note, however, that neither 18 nor 35 is a prime number.

54. The prime numbers less than any chosen number, say 100, can be found in the following way. Write down all the numbers from 1 to 100. Then, starting from 2, strike out every second number (*viz.* 4, 6, 8, etc.). This, of course, removes all multiples of 2. Next, go to the first number above 2 which is not struck out, *i.e.* 3, and, starting from here, strike out every third number (*viz.* 6, 9, 12, etc.). Now take the next number above 3 which is not struck out, *i.e.* 5, and starting from 5, strike out every fifth number (*viz.* 10, 15, 20, etc.)—and so on.

NOTE. In the example just considered it will not be necessary to continue the process after we have started from 11. For on dividing 100 by 11, the quotient is less than 13, the next higher prime. Hence, if any of the numbers are divisible by 13, the quotient must be less than 11, *i.e.* they are multiples of numbers less than 11, and therefore have already been struck out.

55. The prime numbers less than 100 are thus found to be 2, 3, 5, 7, 11, 13, 17, 19, 23, 29, 31, 37, 41, 43, 47, 53, 59, 61, 67, 71, 73, 79, 83, 89 and 97.

Example 1. Is 691 prime or composite?

It is only necessary to find, by trial, whether 691 is exactly divisible by any *prime* number less than 691. For, if it were divisible by any *composite* number, it would plainly be divisible by the prime factors of that number.

By trial, we find there is a remainder in each case when 691 is divided by 2, 3, 5, 7, 11, 13, 17, 19, 23, 29. We need not try any higher number than 29, because the quotient in that case is less than 31, the next prime. [See Note above.]

Example 2. Find the prime factors of 315084.

$$\begin{array}{r|r} 2 & 315084 \\ \hline 2 & 157542 \\ \hline 3 & 78771 \\ \hline 7 & 26257 \\ \hline 11 & 3751 \\ \hline 11 & 341 \\ \hline & 31 \end{array}$$

Here, by trial, we find that 315084 is divisible by 2; the quotient obtained is divisible by 2; the second quotient is divisible by 3; and so on until we obtain a prime number, 31, for quotient.

$\therefore$ 315084 = $2 \times 2 \times 3 \times 7 \times 11 \times 11 \times 31$ *Ans.*

56. In finding the factors, whether prime or composite, of a given number, it is often possible to test its divisibility by another number, without performing the operation of division. The following are some of the most useful cases:

1. Every number is a multiple of 10 + *its units digit.* $\therefore$ a number is divisible by 2 if its units digit is divisible by 2.

Such a number is called an *even* number. A number which is not divisible by 2 is called an *odd* number.

2. Every number is a multiple of 100 + the number formed by its two right-hand digits. But every multiple of 100 is divisible by 4. Hence, if the number formed by the last two digits is divisible by 4, so is the number itself.

NOTE. Since $100 = 4 \times 25$, the same test will show whether a number is divisible by 25.

3. In a similar manner we may show that a number is divisible by 8 (or by 125) if the number formed by the last *three* digits is divisible by 8 (or by 125).

4. For the same reason as in [1], a number is divisible by 5 if its units digit is divisible by 5, *i.e.* if its units digit is 0 or 5.

5. A number is divisible by 3 if the sum of its digits is divisible by 3.

For, consider the number 6237.

We know that

$$\left.\begin{array}{r} 1000 = 999 + 1 \\ 100 = 99 + 1 \\ 10 = 9 + 1 \end{array}\right\} = \text{a multiple of } 3 + 1, \text{ in each case.}$$

Therefore

$$\left.\begin{array}{r} 6000 = \text{a multiple of } 3 + 6 \\ 200 = \text{a multiple of } 3 + 2 \\ 30 = \text{a multiple of } 3 + 3 \end{array}\right\}$$

Hence, by addition,

6237 = a multiple of $3 + 6 + 2 + 3 + 7$, so that, evidently, 6237 is divisible by 3 if $6 + 2 + 3 + 7$ is divisible by 3, *i.e.* if 18 is divisible by 3.

6. In the same way we can show that a number is divisible by 9 if the sum of its digits is divisible by 9.

7. A number is divisible by 11 if the difference between the sum of its first, third, fifth, etc. digits and the sum of its second, fourth, sixth, etc. digits is divisible by 11.

Consider the number 38632.

We know that

$$\left.\begin{array}{rr} 10000 - 1, \textit{i.e.} & 9999 \\ 1000 + 1, \textit{i.e.} & 990 + 11 \\ 100 - 1, \textit{i.e.} & 99 \\ 10 + 1, \textit{i.e.} & 11 \end{array}\right\} \text{are multiples of 11;}$$

Therefore

$$\left.\begin{array}{r} 30000 - 3 \\ 8000 + 8 \\ 600 - 6 \\ 30 + 3 \end{array}\right\} \text{are multiples of 11.}$$

Hence, by addition,

$38632 - 3 + 8 - 6 + 3 - 2$ is a multiple of 11.

It follows, then, that 38632 divided by 11 must leave the same remainder as $(3+6+2)-(8+3)$ divided by 11. Consequently, if $(3+6+2)-(8+3)$, or the difference between the sum of the digits in the odd places, and the sum of the digits in the even places, is divisible by 11, so is the number itself.

HIGHEST COMMON FACTOR

57. A factor which divides each of two or more numbers is called a *common factor* of the numbers. The *greatest* factor which divides each of the numbers is called their *Highest Common Factor*, or their H.C.F.

NOTE. Any number which exactly divides another number is called a *measure* of that number. Hence the H.C.F. of two or more numbers is often spoken of as their Greatest Common Measure, or G.C.M.

58. The H.C.F. of numbers which have been expressed in *prime* factors can be found by inspection.

Example 1. Find the H.C.F. of 42, 70, and 182.

$$\left.\begin{aligned} 42 &= 2\times 3\times 7 \\ 70 &= 2\times 5\times 7 \\ 182 &= 2\times 7\times 13 \end{aligned}\right\} \text{We see that 2 and 7 are common factors.}$$

$$\therefore \text{ H.C.F.} = 2\times 7 = \underline{14\ \textit{Ans.}}$$

Example 2. Find the H.C.F. of 836, 2728, and 10010.

We need not find the prime factors of more than one of the numbers.

$$836 = 2\times 2\times 11\times 19.$$

It is clear that it is only necessary to find which of these factors are common to all three of the numbers. By inspection, 2 is common to all: but 2×2 is *not* common. Again, 11 is common to all: and by trial we find 19 divides neither of the other numbers. Hence, the common factors are 2 and 11.

$$\therefore \text{ the H.C.F.} = 2\times 11 = \underline{22\ \textit{Ans.}}$$

59. When the numbers cannot easily be put into factors, we use another method.

We must first prove that

The common factors of a divisor and a dividend are the same as the common factors of the divisor and the remainder.

Consider the numbers 121 and 341.

If we divide 341 by 121 we get 2 quotient and 99 remainder.

$$\therefore \quad 341 = 2\times 121 + 99 \qquad \text{(Art. 23)},$$
$$\text{or } 341 - 2\times 121 = 99.$$

Now, any common factor of 341 and 121 is also a common factor of 341 and 2×121, and is therefore a factor of $341-2\times 121$, *i.e.* of 99. Or, any common factor of the divisor and dividend is also a factor of the remainder.

Again, any common factor of 121 and 99 is a factor of $2\times 121+99$, *i.e.* of 341. Or, any common factor of the divisor and remainder is also a factor of the dividend.

Hence, the common factors of the divisor and dividend are the same as those of the divisor and remainder.

60. We shall apply this result to find the H.C.F. of 731 and 817.

```
731 ) 817 ( 1
       86 ) 731 ( 8
             43 ) 86 ( 2

   H.C.F. = 43 Ans.
```

EXPLANATION. Divide 731 into 817. The remainder is 86. We have shown that the common factors of 731 and 817 are the same as those of 731 and 86. We now apply the same principle to 731 and 86. On dividing 731 by 86 we get a remainder 43, and we know that the common factors of 86 and 43 are the same as those of 86 and 731, and therefore the same as those of the original numbers. We now divide 86 by 43 and get no remainder, *i.e.* 43 is the highest common factor of 43 and 86, and therefore the highest common factor of the original numbers.

61. If at any stage of the work we see a prime factor of the divisor which is not a factor of the dividend, we may take that factor out, since it is not *common*. Thus, in the above example, 2 is a factor of 86, but not of 731. We therefore take the factor 2 out of 86, leaving 43, and then divide 43 into 731. This is found to leave no remainder, so that the work finishes at this stage.

Again, if at any stage we see a factor which is common to divisor and dividend, it shortens the labour if we take that factor out; but we must remember to include the factor in the H.C.F.

Example. Find the H.C.F. of 6171 and 129129.

We see (Art. 56) that 3 is a factor of both numbers. We therefore divide each by 3, obtaining the quotients 2057 and 43043. Now, 43 is evidently a factor of 43043, and by trial we find it is not a factor of 2057. Hence, we proceed with the H.C.F. of 2057 and 1001.

```
1001 ) 2057 ( 2
        55 ) 1001 ( 18
              451
               11 ) 55 ( 5
```

This we find to be 11. Therefore the H.C.F. of the two given numbers is 11×3, *i.e.* 33.

62. To find the H.C.F. of more than two numbers, we first find the H.C.F. of two, then the H.C.F. of this result and the third number, and so on until we have used all the numbers.

LEAST COMMON MULTIPLE

63. A *multiple* of a given number is a number which is exactly divisible by the given number. A *common* multiple of two or more given numbers is a number which is divisible by each of them. The *Least Common Multiple* or L.C.M. of the numbers is the least number which is divisible by each of them.

64. If the given numbers can be put into prime factors their L.C.M. is readily obtained.

Example. Find the L.C.M. of 30, 63, and 140.

$$\left.\begin{aligned} 30 &= 2\times 3\times 5 \\ 63 &= 3\times 3\times 7 \\ 140 &= 2\times 2\times 5\times 7 \end{aligned}\right\} \begin{aligned} &\therefore \text{ L.C.M.} \\ &= 2\times 3\times 5\times 3\times 7\times 2 \\ &= \underline{1260\ \textit{Ans.}} \end{aligned}$$

EXPLANATION. The L.C.M. must be divisible by 30, therefore it must contain the factors

2, 3, 5. Next, the L.C.M. must be divisible by 63, therefore it must contain the factors 3, 3, 7. But we have already one 3 in the L.C.M., so that we have only to write 3, 7 along with the 2, 3, 5. *Similarly, since the L.C.M. is to be divisible by 140, we see that it must also have another factor 2, 2. Thus the L.C.M. consists of the factors 2, 2, 3, 3, 5, 7.*

65. The above process is usually shortened in the following way.

Example. Find the L.C.M. of 13, 15, 182, 14, 52, and 65.

$$\begin{array}{r|l} 2 & \cancel{13},\ 15,\ 182,\ \cancel{14},\ 52,\ 65 \\ \hline 5 & 15,\ 91,\ 26,\ 65 \\ \hline 13 & 3,\ 91,\ 26,\ \cancel{13} \\ \hline & 3,\ 7,\ 2 \end{array}$$

$\therefore$ L.C.M. $= 2 \times 5 \times 13 \times 3 \times 7 \times 2$
$= \underline{5460\ Ans.}$

EXPLANATION. 13 is a divisor of 65, and therefore any multiple of 65 will also contain 13. Hence we may leave out the 13. Similarly we leave out 14, since it is contained in 182. Next divide by a *prime* number which is a factor of two or more of the given numbers. In this case we see that 2 is a factor of 182 and 26. Divide those numbers by 2, and set the other numbers down with the quotients; thus, 15, 91, 26, 65. We now see that 5 is a factor of two of these numbers. Divide them by 5, and we get 3, 91, 26, 13 for the third line. We now leave out 13 since it is contained in 26. Finally, we divide by 13, which is a factor of 91 and 26. There are now only prime numbers left; and the L.C.M. is the product of the numbers in the last line and of the numbers by which we have divided.

66. If the prime factors of the numbers are not easily seen, we proceed thus. Find the H.C.F. of two of the given numbers, and divide them by their H.C.F. The two quotients can have no *common* factor. Hence (Art. 64), the L.C.M. of these two quantities is

H.C.F. $\times$ 1st quotient $\times$ 2nd quotient.

In exactly the same way we now find the L.C.M. of this first L.C.M., and the third of the given quantities. Evidently this is the L.C.M. of the three quantities. And so on, until we have used all the quantities.

Example. Find the L.C.M. of 16046, 21922, and 23843. By the rule of Art. 60 we find the H.C.F. of 16046 and 21922 is 226. On dividing these two numbers by 226, the quotients are 71 and 97. Therefore, the L.C.M. of 16046 and 21922 is

$226 \times 71 \times 97$, *i.e.* $2 \times 113 \times 71 \times 97$.

By trial, we find the only one of these factors which divides 23843 is 113. Therefore the H.C.F. of the L.C.M. already found and of 23843 is 113. Divide the L.C.M. by 113, obtaining $2 \times 71 \times 97$; divide 23843 by 113, obtaining 211.

Hence the L.C.M. of the three given numbers is

$113 \times 2 \times 71 \times 97 \times 211$.

67. To find the H.C.F. or the L.C.M. of compound quantities we must first, by reduction, *express them as simple quantities* in terms of the same unit.

Example. Find the H.C.F. and L.C.M. of 7 qrs. 14 lbs.; 3 cwts. 1 qr. 26 lbs.; 4 cwt. 14 lbs.

Reduce each quantity to lbs. as in Art. 38. Then,

$$\begin{aligned} 7 \text{ qrs. } 14 \text{ lbs.} &= 210 \text{ lbs.} = 2 \times 3 \times 5 \times 7 \\ 3 \text{ cwt. } 1 \text{ qr. } 26 \text{ lbs.} &= 390 \text{ lbs.} = 2 \times 3 \times 5 \times 13 \\ 4 \text{ cwt. } 14 \text{ lbs.} &= 462 \text{ lbs.} = 2 \times 3 \times 7 \times 11 \end{aligned}$$

Hence, H.C.F. $= 2 \times 3 = \underline{6 \text{ lbs. } Ans.}$

L.C.M. $= 2 \times 3 \times 5 \times 7 \times 11 \times 13$
$= 30030$ lbs.
$= \underline{13 \text{ tons } 8 \text{ cwt. } 14 \text{ lbs. } Ans.}$

68. We add some miscellaneous examples.

Example 1. Find the least number which, when divided by 15, 21, 35, or 45, always leaves remainder 12.

$$\begin{array}{r|l} 3 & 15,\ 21,\ 35,\ 45 \\ \hline 5 & \cancel{5},\ \cancel{7},\ 35,\ 15 \\ \hline & 7,\ 3 \end{array}$$

L.C.M. $= 3 \times 5 \times 7 \times 3 = 315$

$\therefore$ Required no. $= 315 + 12$
$= \underline{327\ Ans.}$

EXPLANATION. The least number which, when divided by 15, 21, 35, or 45, leaves *no* remainder, is their L.C.M., which is 315. $\therefore$ the smallest number which leaves remainder 12 is $315 + 12$.

Example 2. Find the greatest number which, when divided into 9505 and 20840, leaves remainders 49 and 155 respectively.

If the number divides 9505 and leaves a remainder 49, it must divide $9505 - 49$, *i.e.* 9456, and leave no remainder.

Similarly, it must divide $20840 - 155$, *i.e.* 20685, and leave no remainder.

9456) 20685 (2
1773) 9456 (5
591) 1773 (3

Required number $= \underline{591\ Ans.}$

Therefore, the number required is the H.C.F. of 9456 and 20685.

Example 3. A man walking along a road notices a mile-stone standing against a telegraph pole. He finds the telegraph poles are 66 yards apart. How far will he walk before he again finds a mile-stone against a telegraph pole?

He will evidently have to walk a distance which contains 66 yards an exact number of times, and which also contains 1 mile an exact number of times. The *least* distance he must walk, then, will be the L.C.M. of 66 yds. and 1 mile, *i.e.* of 66 yds. and 1760 yds. This is found to be 5280 yds., or $\underline{3 \text{ miles } Ans.}$

To be continued

Group 2
ART
2
Continued from page 184

DRAWING & THE HUMAN FORM

Choice of Work. How to "Block in." The Power of Line. Aids to the Artist's Career. Drawing from Life. The Human Form

By P. G. KONODY

The Artist's Choice of a Career. The student on the threshold of an artistic career should be very decided as to what branch of art he intends to master. If all his joy be in colour, he should give his strength to so mastering colour that it shall express the mood of the thing he wishes to create; and he should at the same time remember that there are other ways of painting, often vastly more lucrative, than the mere making of easel pictures. He should look to the career which will give him the greatest scope for his powers and the largest outlet for employment—such as the decoration of the walls of houses. Then, again, the illustrating of books and papers created some of the noblest art of the last fifty years. This field is to-day seriously damaged by the widespread use of photography; but photography can never compete with the creative artist in invention, and for the man of ideas there is still scope even in illustration, though the field is very limited. There is, on the other hand, wide scope for the employment of his art in advertisement such as the designing of the picture poster.

If, however, his joy be form, and he decide to be a sculptor, the same advice applies to him, for whilst his chances in selling the imaginative piece must always be limited, there is wide scope for him in the modelling of beautiful articles for everyday use and in creating decorative sculpture for buildings. In short, let nothing be too large or too small for the exercise of the artist's gifts—the more he does, the more facile will become his hand's skill in creation. There was never such a crying need for the beautifying of life by making every utensil and adornment in the home and in the street a joy to the eye.

What He Must Teach Himself. Having decided, then, on the province of art which he will make his own, the student is at once brought face to face with the serious question of training and pupilage. It is evident that the student will have to go through a certain amount of schooling in order to learn modelling in clay if he desire to become a sculptor, or the handling of paint if he wish to become a painter; but it is astounding how much he can learn even of these things in a short time, if he will first of all teach himself what he can alone learn by his own application and taste—to draw. Some men have risen to fame without more schooling in the arts than they could get from their own industry and the fellowship of other students. But whether a man be blessed with the inestimable advantages of seeing the great masters at work, or, better still, of working in their studios as pupil; or whether he may have to discover the craftsmanship of his art step by step for himself, there is one thing above all others that he *must* teach himself, and that is to draw with ease anything that may come his way, so that drawing becomes a habit. Drawing is to the artist what words are to him who would speak well; and just as a thorough grasp of English enables a man to speak it without any conscious effort, so a thorough mastery of detail should enable the artist to draw with such facility that his mind is not harassed by any of the countless difficulties which bewilder the student at the beginning.

The Habit of Drawing. This habit of drawing, which is at the base of everything that an artist does, which is in fact beneath every brushful of paint before that paint can be placed exactly where he wishes to place it, which is beneath the stroke of the chisel before the chisel can be made to yield form—this habit of drawing is the base and foundation of everything the artist does or may ever hope to do. And this art of drawing he *must teach himself*, whether he go to an art-school or become the pupil of a master, and by his own powers and gifts alone can he acquire it. He cannot begin too soon, for he must go through an ugly, hard, rigid stage of striving before the secret comes to him—nothing is too humble for him to draw. One day mastery may burst upon him almost as by magic, and he will find his hand drawing any form he desires to express, just as, in learning to read, his eye takes in the word without spelling it.

It is clear, therefore, that it is a waste of time to enter a class of painting before the hand can obey the will in its desire to express the form of things; let us therefore proceed to show the way along the road to art by showing what the student must teach himself; and when he is fit to take advantage of the schools we will lead him thither and through.

Drawing from Memory. Besides drawing direct from nature the student should practise from the outset memory drawing. He should try to record with his pencil what his eye has observed in street or field. And if he fail, let him go out and look again, and then correct his drawing until he is satisfied with the result. He will find this especially useful for the expression of movement, and his eye will soon acquire the custom of retaining each successive stage of rapid motion. This is the method of training followed by the Japanese, and in it lies the secret of the charm of Japanese art, which expresses with bold simplification the salient points which the eye can take in at a quick glance, omitting the detail which can only be observed in complete repose.

How to "Block in." The student's first step, then, is to use drawing as a habit. Now, the tendency of the beginner, when he starts to draw an object, is to begin with details, which is disastrous. He should first of all "block" in the mass, as it is called, then "block" in the mass of the detail, and then get the *accurate* forms. For instance, in sketching the human figure, first roughly sketch the main proportions so as to get the swing and action and general relations of the parts one to the other, so as to get the proportions right; then roughly sketch the general form of the details of the head and limbs; then with telling lines get the true form of the features and the wondrously beautiful lines of the limbs, so that when even the outlines of the figure are drawn, they seem to hold the forms and state their character and suggest flesh.

It is a good thing—indeed it is the best master in the wide world—to collect prints and cut out of old magazines good drawings by well-known artists, and to copy them—not only the work of one man, but the work of many, so as to learn to say with line what they could say. The choice of the masters will depend upon the taste of the student; but the chalk portrait heads of Holbein, the many sketches in chalk by Lord Leighton, and the clear, firm drawings of such popular draughtsmen as Phil May, Randolph Caldecott, and the like, are invaluable guides to drawing; whilst Sir Edward Poynter issued a series of drawing-books for students of the antique which are good training in chaste, clear line of the beauty of form to be learnt from the great Greek sculptors. It is capital practice, too, to get photographs of well-known people and of beautiful women, and to sketch them in line, always remembering to "block in" the whole head first, then to draw the details in their true relation to each other afterwards. Indeed, the very collecting of

"THE SOWER," BY J. F. MILLET

"THE GLEANERS," BY J. F. MILLET

Both these pictures illustrate the power of line: "The Sower," by its noble swing, suggests the mastery of man over Earth. "The Gleaners," by its curves, suggests Earth enslaving man

good examples of drawing will train the eye far better than all the directions that could possibly be given.

Detail. The rough lines to "block out" the object are, needless to say, only to give a rough idea of where the real form will come; but when the details are drawn, then every line should be so true that the very object seems to be enclosed within them. In the first rough sketch of the general form and swing of the figure, for instance, we are only seeking to get proportion, and the general idea of the ground to be covered. But the drawing of the detail that will then be set within this rough sketch cannot be too true or too beautiful in its effect upon the eye.

Exactly the same advice applies to a landscape. Rough sketch the relation of things as a whole, roughly showing where the masses of dark and light will come, and the general lines. Then sketch in the details, which will not now get out of place.

It used to be the habit in the art schools to set a pupil to draw a Greek statue, and laboriously spend weeks and months in stippling and cross-hatching the light and shade of every detail of it; but this is a pitiful waste of power which should be applied to the acquiring of ease, deftness and swiftness in setting down the form of things. And even if a student be attending an art school, all his work there will be empty of result if he is not constantly drawing as swiftly and well as he possibly can every object that he sees about him. Then, when the day comes that he awakes to find drawing a habit, he will not only be able to paint without being harassed with the difficulty of drawing, but he will be able to concentrate all his powers upon getting the colour true. Many a boy has come to hate literature because he was compelled to learn Shakespeare before he could understand him; in the same way art is choked out of many a lad by the boring and tedious effort to draw objects like old statuary until he hates every detail of the beautiful object.

Everything holds a character of its own, and that character can be given by drawing. It used, for instance, to be a stupid axiom amongst artists that trousers were without any character but that of stove-pipes; but men like Phil May came and proved that the lines and forms of trousers contained an astounding amount of character, whether they were the ragged wear of beggars, the dandified grotesqueness of costermongers, or the inherited breeches of street-boys. Boots hold a rare amount of the character of the feet they cover, character which they betray to the man with eyes sufficiently inquisitive to seek them out and draw them.

Line. Now as regards the line. The student should draw with the line as the musician uses a note of music on a violin—making the line swing out or thin down as it suits the form he would draw. It is an education to look at one of Holbein's chalk portraits to see how the line caresses the form of the brow, and seems to disappear over the curved edge, to start again and sweep over the cheek bone. The line as it forms the nose seems to search out every subtle curve and form, until it disappears into the flesh under the nostril. Then, again, take a pen drawing by Aubrey Beardsley—see how musical is the sense it gives. When the line with its simple curve sweeps round the edge of the head, neck and shoulders of some beautiful woman, it seems to be made of delicate flesh—it suddenly breaks into a series of dots that seem to be made of very muslin, tracing the delicate folds of gossamer draperies—then the line takes a stronger note and sweeps out the form of the silken gown, rippling along to make the flounces, and criss-crossing net-wise to state the netlike quality of some transparent veil. There is scarcely any master who could do more with the sheer beauty of his line than Beardsley, whose work is easily within the reach of any student. There are lessons innumerable in Randolph Caldecott's nursery books, not only of how line

JOHN FISHER, BISHOP OF ROCHESTER, BY HOLBEIN
To illustrate the freedom and power of the master's line
[From the original in Windsor Castle]

properly and fitly handled can *speak* to the eye, but also in the great beauty of colouring achieved by simple broad washes of water-colour—an excellent practice which greatly enhances the value of a pencil drawing, or of a drawing done with indelible black ink, which may be bought from any artists' colourman.

Modelling. At the same time that the student is mastering pure line, he should not only use the pencil and the pen, but he ought from the very first to draw with the brush as well, getting his hand used to the loose point and the tricks of the tool. He should try to get a copy of the "Studio's" special number upon "Modern Pen Drawing," and Joseph Pennell's most useful volume on pen drawing, with its invaluable examples by various artists, a book which is an education in itself, since it shows what wondrous beauty can be produced by sheer line.

It would be better still for the student to collect a book of his favourite drawings and so develop his own taste. And there are innumerable superb examples of the work of Edwin Abbey, Howard Pyle, Dana Gibson, and others in the American magazines, which are better than much schooling. At foreign booksellers may be procured for a few pence the work of Frenchmen like Steinlen, and of Germans and other foreign artists in papers like *Jugend* and *Simplicissimus*, which are not only a joy to possess, but which are also a rare education in drawing. Also, from the beginning, whilst the student is still giving all his strength to the mastery of drawing, he should try to sweep in broadly the modelling of the masses; not going into the details as in the old academic methods, but still getting the larger values. Thus, when he acquires correctness in drawing, he will be able to model in the detail with ease.

A very useful thing, until the student can afford the schools, is to get photographs of horses, dogs, animals, or people, whether in magazines or otherwise, and try to draw them in freehand.

The Human Form. We now come to drawing from the human form. A certain amount of anatomy may be learnt from books on this subject, but the best way to learn it is to take the male figure and the female, and to *draw* them into your knowledge. Mere reading of books on anatomy is sheer waste of time. The chief muscles and the bones should be *drawn*, so as to give the hand the knowledge as well as the head. The student will find that when he draws a head, he is inclined, as he goes on drawing the figure, to elongate each part more and more out of all proportion to the head. Some students are inclined to do the opposite and shorten the proportions—a very ugly fault.

It is best in drawing from life, to tick off the proportions so as not to let the pencil stray, as it is inclined to do, into elongation. The figure roughly divides into two at the top of the legs, and artists make the head the standard of measurement, always speaking of the figure or parts of the figure as so many "heads." The height of the head goes into the upright figure seven and a half times (the Greeks made it eight, as we shall see). The first head is, of course, to the chin, the second *head comes to the nipples of the breasts, the third head to the navel, and the fourth head to the top of the legs. This is half the figure, or the whole of the head* and trunk.

The fifth head comes down the thigh so far as to allow the knee to come midway between it and the next head, the sixth; while the seventh head reaches to the ankle. The foot, then, is midway in the eighth head, as the knee was midway in the sixth.

A Permissible Exaggeration. The Greeks made the shin longer, so that the foot came to the eighth head, and the figure acquired an added grace and dignity due to the length from the knee to the heel. It is a very permissible exaggeration, often employed with fine effect by men like Leighton.

The length of the figure kept within check, the student is not liable to go very far wrong with its breadth; but it is well to have a rough rule of thumb for the face

BOY: "No? Why, don't you *never* treat yourself to no luxuries, guvner?"

THE EXPRESSIVENESS OF LINE: A PEN-AND-INK DRAWING BY PHIL MAY.

HERMES, BY PRAXITELES

THE VENUS OF MILO

THE GREEK IDEAL OF BEAUTY

and head also. The face is halved across the eyes; the nostrils form the quarter line (or half the lower half). The hair, roughly speaking, forms the upper quarter (or half of the upper half). The ears should in the full face therefore come between the cross line of the eyes and the cross line of the nostrils. The width of the face is roughly twice the length of the nose, or twice the length from the nose to the chin.

It is well constantly to draw the male and female figure from memory—back, front, and side view—until the proportions are so set in the memory as to become fixed; in fact, the student should be able to draw them almost with his eyes shut. It is astonishing how accurate the brain becomes in holding these facts when drilled to it—just as it holds pages of verse by training, stored away until called for. These six forms, three of the male and three of the female figure, are enormously valuable to the artist's memory and hand.

To be continued

Group 23
NATURAL HISTORY
3
Continued from page 174

HOW A FLOWER IS BORN

Maintenance of the Life of the Species. Germination and Development of Seeds. Structure and Parts of Flowers and Plants. Classification

By Professor J. R. AINSWORTH DAVIS

HOWEVER successful an individual plant or animal may be in the struggle for existence, the species to which it belongs would of course die out were there not some provision for the production of new individuals. And we find that in all organisms parts of the body become detached and ultimately grow into the members of a new generation. This process is *reproduction*, or *propagation*, and may be effected by seed-plants in a variety of ways.

Kinds of Reproduction. A broad distinction is drawn between *vegetative reproduction*, in which some of the parts helping in the maintenance of the life of the individual become detached, and *sexual reproduction*, which is of more specialised nature, and is ministered to by the flower.

Good examples of the former are afforded by the potato and strawberry. What is familiarly known as a "potato" is really a thickened branch of an underground stem, crammed with starch and other kinds of nutritive matter and technically called a *tuber* [40]. If allowed to remain in the ground the *eyes*—which are really buds—will grow into shoots that rise above the surface, while roots grow out from their lower nodes. The result is a new plant. As everyone knows, this valuable article of food is usually propagated by means of the tubers, which are cut into pieces, care being taken that each of these possesses at least one eye or bud.

In the case of the strawberry, long thin branches, the *runners*, grow along the ground away from the parent plant. From every node roots and a shoot can be produced, which grow downwards and upwards respectively [41]. By decay of the internodes the connection with the parent is lost, and a number of young distinct plants are the net result.

The Flower. Some of the branches of the stem in our pattern plant, instead of giving rise to nothing but ordinary foliage-leaves, bear one or more flowers, into the nature and use of which we must now inquire. We will suppose these to be "pattern flowers," answering to the general plan of which all flowers are variations, just as we may look upon the many kinds of clock and watch as being modifications of a pattern or diagrammatic time-piece, such as a teacher of clock-making might devise to illustrate the essential parts common to all pieces of mechanism—apart from such things as sun-dials—of which the use is to tell the hour of the day or night.

The flower is in reality a greatly specialised shoot, concerned with the production of healthy seeds, capable of growing into fresh plants. Like all shoots, it is a stem bearing leaves, though these differ more or less from ordinary foliage-leaves, in accordance with their different use. It is borne on a *flower-stalk*, which may also bear simplified and often scale-like leaves known as *bracts*.

Parts of the Flower. Consider the parts of the flower [42]. The central stem-part, the *receptacle*, is very short, owing to the suppression of its internodes, so that the different flower-leaves which it bears are crowded together, much in the same way as are the foliage-leaves in the rosettes of the dandelion and daisy, to which allusion has elsewhere been made. The flower-leaves are of four kinds, arranged in two sets, (a) the *perianth* or *covering-leaves* externally, and (b) the *essential* or *reproductive leaves* internally.

The two sets of leaves of which the perianth is composed are an external circlet or *whorl* of five *sepals*—collectively termed the *calyx*—and an internal whorl of five *petals*, alternating with the sepals and together making up the *corolla*.

The *Sepals* are firm and green, being more like foliage-leaves than their associates. They protect the delicate internal parts of the flower, especially in the bud.

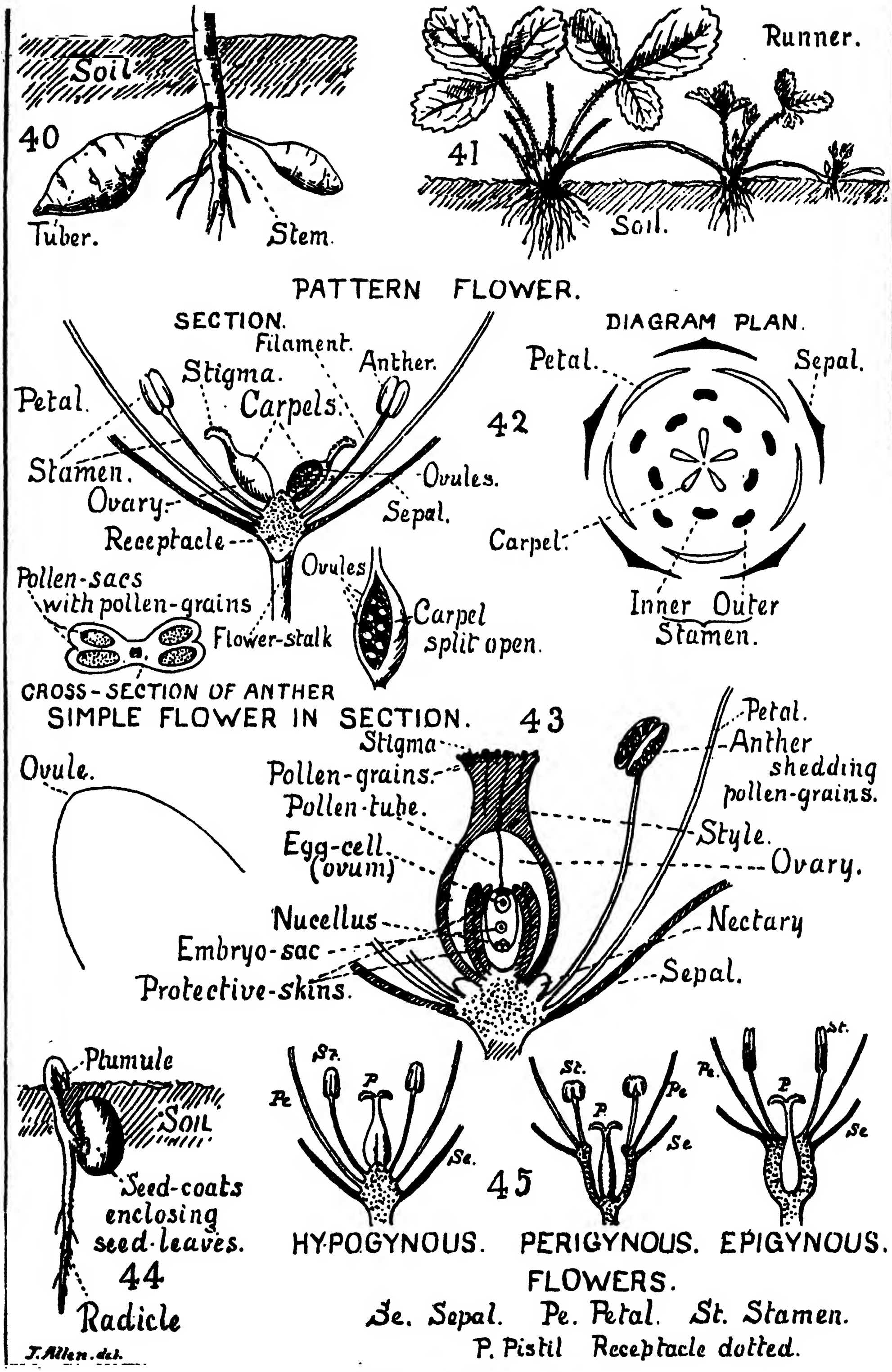
The *Petals* are larger and more delicate than the sepals, and are brightly coloured. They help to protect the essential leaves, but their chief use is to make the flower conspicuous, in order to attract insects. The object of this will presently become apparent.

Reproductive Leaves. In the essential or reproductive leaves, again, we have two sets of structures—*i.e.* two whorls of *Stamens*, five in each whorl, and a whorl of five *Carpels*. The members of each whorl alternate with those of the preceding one.

The *Stamens*, which are to be regarded as the male part of the flower, differ greatly in appearance from the petals and sepals. Each of them is like a thread with a thickened end, the two regions being the *filament* and *anther* respectively. In the latter is produced the *flower-dust*, or *pollen*, which probably everybody has noticed in a lily or tulip. If a young anther is cut across and examined under the microscope it will be found to contain four pollen sacs in which the particles of this yellow dust, the *pollen-grains*, are formed. They are essential to the formation of the seed, as we shall presently see, and are liberated by the splitting of the anthers.

Except that the *Carpels* are green, they differ widely in appearance from leaves, but each of them is really a folded leaf, of which the two edges have coalesced. Sheltered within the cavity are a number of minute green bodies, which grow out from the edges of this folded leaf,

TYPES OF FLOWERS



PATTERN TYPES OF FLOWERS

[The figures 31–39 in this section refer to the corresponding figures in the Frontispiece]

as will be realised when the carpel splits open later, as it does, *e.g.* in larkspur (*Delphinium*) or marsh marigold (*Caltha*). The ovules are destined to become the seeds, provided the pollen-grains are allowed the chance of performing their office. The lower ovule, containing part of a carpel is the *ovary*, and its narrow upper end is the *style*, on the top of which is a sticky patch, the *stigma*. The carpels are the female part of the flower, and are collectively termed the *pistil*.

Production of Seeds. In order to clearly understand how ovules become seeds it will be best to leave our pattern flower, and consider a still simpler case, where only one carpel is present, in which but one ovule is contained [**43**]. Microscopical examination will show us that this ovule is covered by two protective skins, imperfect, however, at one place—the *micropyle*, which is simply the Greek for "little gateway." Within these skins is a cellular mass (*nucellus*), one cell of which, close to the micropyle, has developed into a relatively conspicuous structure, and is known as the *embryo sac*, because within it the young plant is formed.

The most important part of the contents of this sac is the *egg-apparatus*, a group of three small cells next the micropyle. One of them, which is much larger than the others, is the *egg-cell*, or *ovum*, from which the young plant originates, and which is strictly comparable to the egg of a fish, a frog, or an insect. But its development cannot begin unless it is *fertilised*—*i.e.*, unless an infinitesimal amount of what may be called male protoplasm fuses with it. It is the office of the pollen-grain to supply this. And here it may be stated, once for all, that sexual reproduction in plants and animals alike essentially consists in the coalescence of two minute masses of living matter, or protoplasm, one male and the other female. We do not at present precisely know why fertilisation should be necessary, or exactly how it makes it possible for the egg-cell to develop.

The Birth of a Plant. [**43**]. A pollen-grain is a small mass of protoplasm containing two *nuclei*, and covered by two skins, of which the inner one is very delicate. It may be regarded as consisting of two cells—as indicated by the two nuclei—though in the higher seed-plants these are not separated from each other by a party-wall. The first step towards the attainment of fertilisation is the transfer of pollen-grains to the stigma. This is *pollination*.

Supposing this transfer to have been accomplished, the pollen-grain germinates in the sticky fluid of the stigma, and sends out an excessively delicate *pollen-tube*, which grows down through the style into the ovary, where its tip passes through the micropyle. Meanwhile, one of the two nuclei of the pollen-grain has passed into the pollen-tube, where it divides into several fragments. One of these enters the ovum, with the nucleus of which it fuses, and thus effects fertilisation. It has just been said that this process consists in the union of two minute masses of protoplasm, and we may add to this that the masses in question are of nuclear nature,—*i.e.* they are made up of *specialised* protoplasm. The nucleus of a cell is, in fact, of an extraordinarily complex nature, but it would take us too far to enter into details regarding this.

Supposing that the pollen-grain of our simple flower has been transferred to the stigma of the *same* flower, it will be a case of *self-pollination*, followed by *self-fertilisation*. But if the pollen-grains on the stigma have come from *another* flower we have *cross-pollination*, followed by *cross-fertilisation*.

How Insects Beautify the World. As a result of very numerous observations and experiments it has been clearly proved that healthier and more vigorous seeds are produced when cross-fertilisation takes place than when the egg-cells are self-fertilised. We do not quite know why, but such is the case. Pollen from another flower on the same plant is better than pollen from the same flower, while if it has been produced in a different plant of the same species the results are still more favourable.

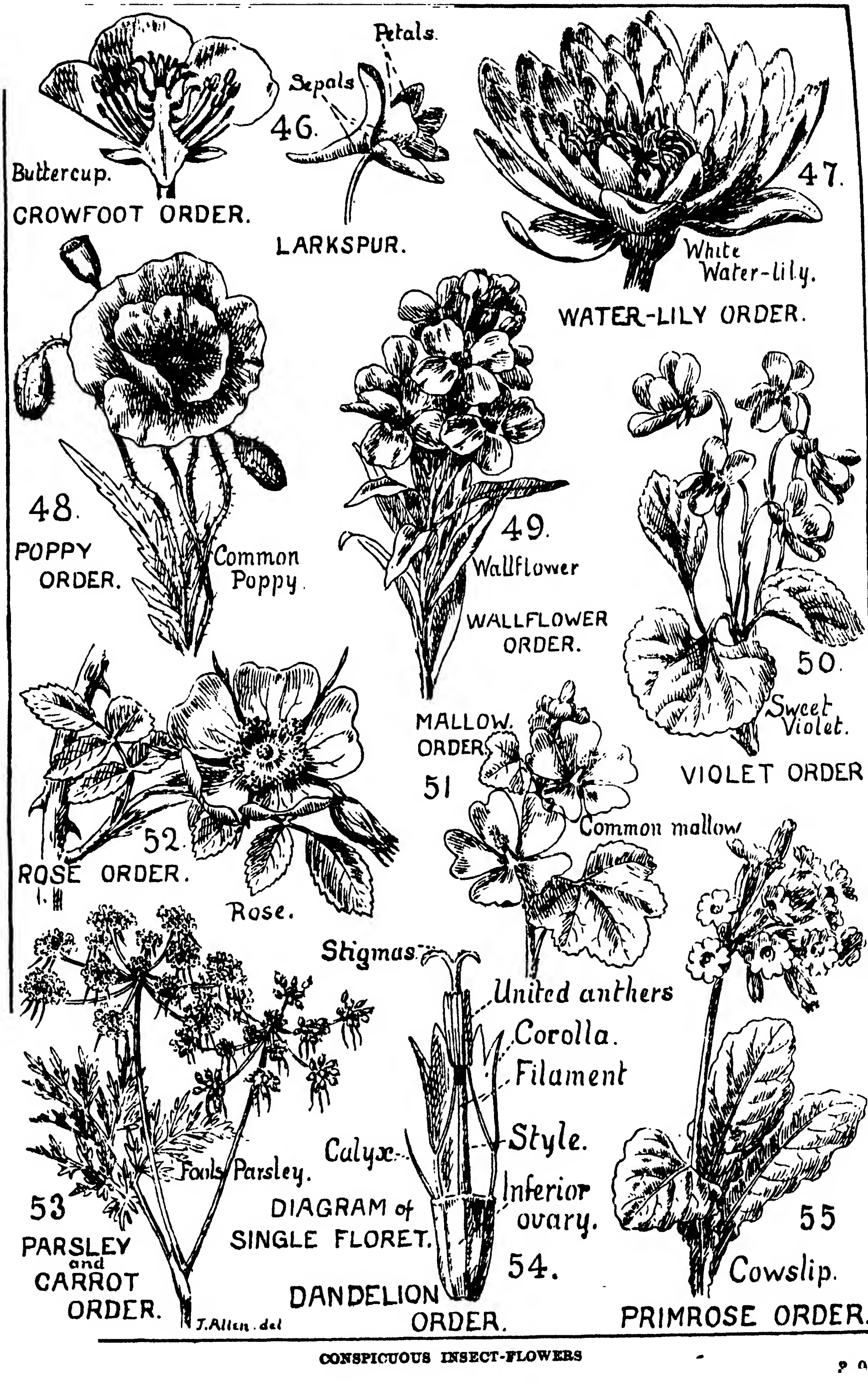
As cross-fertilisation is necessarily preceded by cross-pollination, we naturally expect to find many devices for securing this. Pollen may be transferred from one flower to another by various agencies. If we suppose our simple flower to be a *conspicuous* one, the transfer will most likely be effected by insects—*i.e.* it will be *insect-pollinated*.

The *colours* and *odours* of our native flowering plants are simply to be regarded as means for attracting insects, though fortunately enough these have for the most part similar predilections in these matters to ourselves. Indeed we may say that our æsthetic tastes, so far as sight and smell are concerned, have evolved to a large extent on lines determined by the insect world.

Flowers, however, do more than merely attract insects by suitable colours and odours. They provide them with what may be called *flower-food*, upon which indeed some of their guests are entirely dependent. This partly consists of the *pollen* itself, which is produced in abundance, and partly of the sweet fluid known as *nectar*. The latter oozes out from little swellings—*nectaries*—situated deep down in the flower, and varying a good deal in number, character, and exact position.

The fertilised ovum divides again and again to produce a small mass of cells, which enlarges and increases to form a minute plantlet, outside or within which is a store of food in the form of starch and albuminous matter, or possibly other nutritive substances which render growth possible till such time as the young plant is able to draw on the supplies of the outside world. The delicate investments of the ovule become firm and tough *seed-coats*.

The Fruit. While the seeds are ripening the ovary enlarges and becomes the *fruit*. This may be hard and dry, as in buttercup, poppy, and sunflower, or fleshy and succulent, as in plum, orange, and grape. Other parts besides the ovary may undergo changes, and contribute to the formation of what is then termed a "false fruit." The red pulp of a strawberry, for instance, is formed by the enlargement of the



CONSPICUOUS INSECT-FLOWERS

stem-part of the flower,—*i.e.* the receptacle. The little brown pips which stud its surface are the real fruit—in this case dry, and each formed from an ovary.

The diverse characters of seeds and fruits are often in relation to the necessity for giving the young plants a chance of finding some suitable spot in which to grow up, and for preventing them from competing too vigorously with their parents. We have, in fact, all sorts of arrangements by which the *scattering* or *dispersal* of seeds is facilitated.

Germination of the Seed [44]. If a bean is soaked in water and the tough coats removed, we shall find the interior entirely occupied by the young plantlet, which consists of a very small root (*radicle*), a shoot (*plumule*), and two relatively enormous seed-leaves (*cotyledons*), in which food is stored. By treating a castor-oil seed (easily obtainable from the chemist) in the same way, we shall also be able to make out radicle, plumule, and cotyledons, but these last are quite thin and do not act as storehouses. In this case the plantlet is embedded in a mass of nutritious substance, known as the *endosperm*, or often as the "albumen," a not very happy name for it. The two seeds named are types of *exalbuminous* and *albuminous* seeds, in which the food of the young plant is stored up within it and outside it respectively.

During the winter the seed remains in a dormant condition, but when spring arrives it begins to grow—*i.e. germinates*. The seed coats crack, the radicle elongates and pushes its way into the soil, while the plumule also becomes larger and longer, rising into the air and unfolding its leaves. The food store is gradually exhausted in these processes of growth, becoming converted into soluble substances, which travel to the places where they are required. By the time they are all used up the seedling plant is able to take its food from the air and soil. Moisture, oxygen, and warmth are required for germination.

CLASSIFICATION OF SEED-PLANTS

We have already seen that the seed-plant phylum (*spermophytes*) is divided into pod-plants (*angiosperms*) and naked-seeded plants (*gymnosperms*), and some details regarding the subdivisions of the former may now be given sufficient to serve as an introduction to special works on the subject. Pod-plants are divisible into two *classes*, as follow:

Class I. Dicotyledons. The seedling is provided with two cotyledons or seed-leaves, and the vascular bundles of the stem are arranged in a ring, each of them containing *cambium*, which is able to bring about increase in thickness. The veins of leaves are arranged in *net-like* fashion. Whorls of the perianth in 4's or 5's.

Class II. Monocotyledons. The seedling is provided with only one cotyledon, and the vascular bundles of the stem are scattered and devoid of cambium. The chief veins of the leaves are generally more or less parallel. Whorls of the perianth in 3's.

100,000 Species. As over 200 orders are recognised (of which about 90 are British), embracing something like 100,000 species, it is obvious that we must limit ourselves to the consideration of facts of leading importance.

The characters used in classification are of the most various kind, and though in most cases there is no doubt some practical meaning to be attached to them, our knowledge as to that meaning is often incomplete.

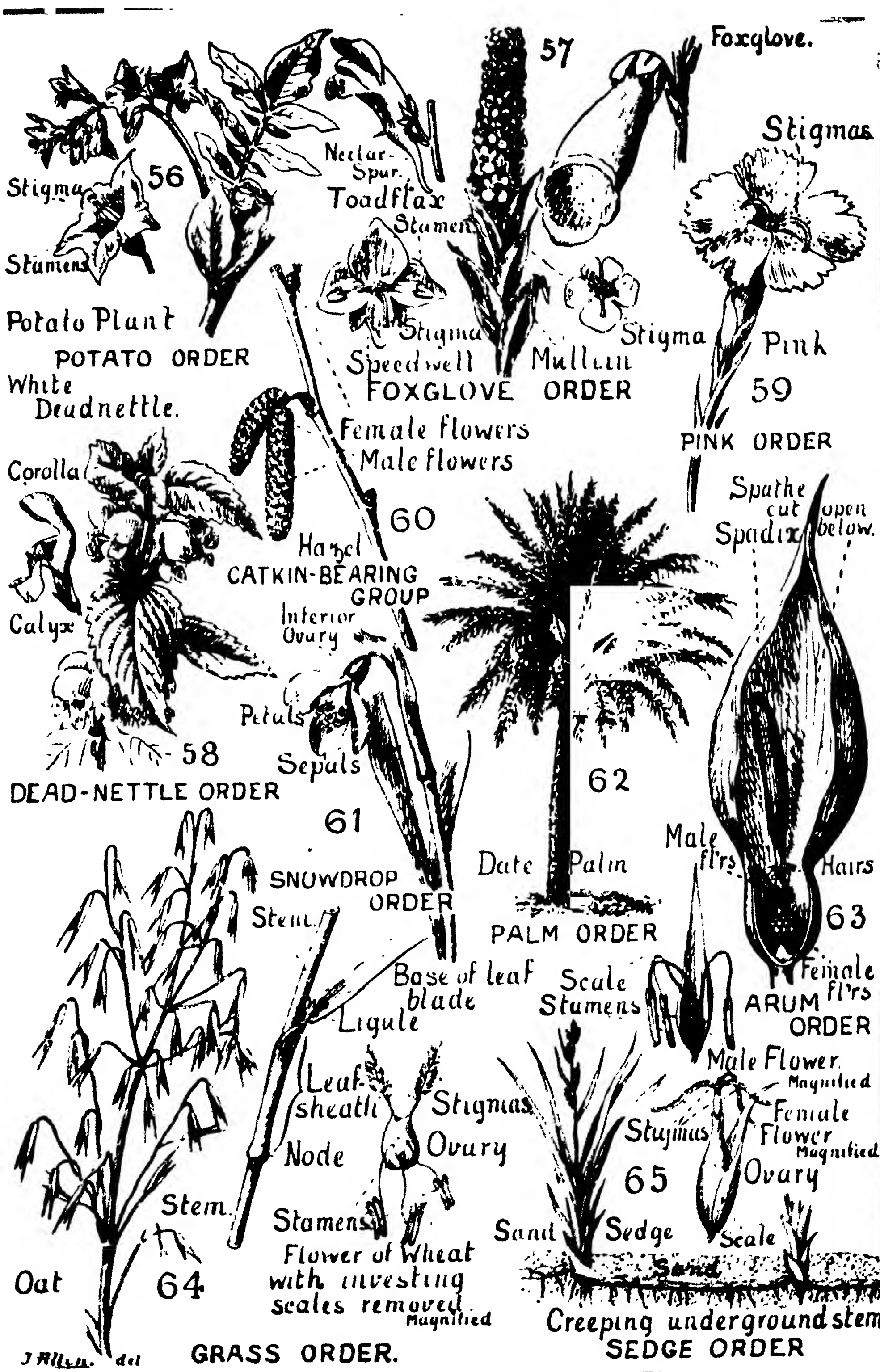
We find that *foliage-leaves* vary greatly in arrangement and shape; while stipules may be present or absent. As to the first point, which largely has reference to advantageous disposition with reference to light, we may find either only *one* leaf per node, the successive leaves being arranged in a spiral, or there may be *two* leaves at each node. In these two cases the leaves are said to be respectively *alternate* and *opposite*. The shape, as we have elsewhere seen, is often also related to the supply of light. In *simple* leaves the blade is one piece, in *compound* ones it is cut up into a varying number of distinct leaflets. Leaves devoid of stipules are said to be *exstipulate*.

The Structure of a Flower. Great importance attaches to the arrangement and structure of the parts of the *flower*, in which we can often detect some connection with the way in which pollination is effected. In our pattern flower the parts of each whorl of the perianth were all alike, and disposed in a starlike manner. Such a flower is *regular*. But in flowers which are pollinated by the higher insects, such as bees and butterflies, we find that these parts are more or less unequal, and disposed in a two-sided fashion. These are termed *irregular*—*e.g.* pea, pansy, and larkspur.

In simpler cases the *receptacle* is more or less conical, so that the sepals, petals, and stamens clearly spring from beneath the pistil. The flower is then *hypogynous*, as in our pattern case. But the receptacle may be modified into a sort of cup, from the edge of which sepals, petals, and stamens arise, while the pistil occupies the interior of the cup, as in the rose. Such flowers are *perigynous*. And if this cup fuses with the pistil, so that the sepals, etc., appear to grow from the top of the ovary, as in the snowdrop, the flower is *epigynous*, and is still further specialised. In the two first cases the ovary is only attached to the receptacle by its base, and is said to be *superior*, while in the last case the attachment is more extensive, and it is termed *inferior* [45].

The Parts of a Flower. There are many variations as to the *number* of flower leaves. The most primitive case is where they are relatively numerous, and arranged in a spiral. This is beautifully seen in the sepals, petals, and stamens of the white water-lily (*Nymphæa alba*), which pass gradually into one another; also in the stamens and carpels of buttercups (*Ranunculus*).

In most flowers, however, the parts are in successive whorls, as in our pattern case, but there are many variations as to number. The inner whorl of *stamens* is often suppressed



CONSPICUOUS INSECT-FLOWERS AND INCONSPICUOUS WIND-FLOWERS

altogether, and in extreme cases—*e.g.* most orchids—only one stamen may be present. Such reductions have reference to increasing certainty of pollination, so that there is no need for a large quantity of pollen to be produced. The *carpels*, too, for similar reasons, are often reduced in number, and many flowers—*e.g.* pea and gorse, possess but one.

The *perianth* is badly developed, reduced, and inconspicuous, or even absent, where pollination is not effected by insects (or birds), so that there is no need for conspicuousness. In such cases, there is usually an absence of colour (other than green), odour, and nectar.

In simpler cases the flower-leaves of a particular kind are not united together, *i.e.*, are *free*. With increasing specialisation we find sepals, petals, stamens, and more particularly carpels, are respectively *united*. Flower-leaves of different kind may also adhere together—*e.g.*, stamens with petals, as in primrose (*Primula vulgaris*).

There is further a great deal of variation as regards the number of *ovules*, and the way in which these are arranged in the ovary. *Seeds* may be either exalbuminous or albuminous, as already mentioned

We are now in a position to briefly summarise the characters of the more important subdivisions of Dicotyledons and Monocotyledons. The flowers are hypogynous and the ovary superior unless otherwise stated.

SEED-PLANTS.—CLASS I. [Dicotyledons.]

This class is divided into three sub-classes, the flowers belonging to the first two of which are commonly conspicuous, which means that they are pollinated by insects, or it may be in the warmer parts of the globe by birds.

SUB-CLASS 1. *Polypetalæ*. Both calyx and corolla present. Petals free.

a. Buttercup and Water-Lily Group (*Ranales*). Stamens generally numerous. Carpels usually free. Seeds albuminous.

1. CROWFOOT ORDER (*Ranunculaceæ*) [**46**]. Leaves generally alternate and exstipulate. The buttercups and their allies possess regular flowers, with numerous stamens and carpels, while in forms such as larkspur (*Delphinium*), and monkshood (*Aconitum*), there are showy irregular flowers specialised in relation to the visits of higher insects, and fewer carpels.

2. WATER-LILY ORDER (*Nymphæaceæ*) [**47**]. Marsh or aquatic herbs, such as white water-lily (*Nymphæa alba*), and yellow water-lily (*Nuphar luteus*), with conspicuous flowers, the spiral arrangement of which has already been mentioned. Notable species are the Egyptian lotus (*Nymphæa lotus*), and *Victoria regia*, a South American form, with leaves 6 ft. and flowers 16 ins. in diameter.

Barberry (*Berberis*) and magnolia belong to other orders of this group.

b. Poppy, Wallflower, and Violet Group (*Parietales*). The chief peculiarity of this group consists in the fact that the two or more carpels present are united together by their edges, so that the ovules are attached to the outer wall of the ovary.

3. POPPY ORDER (*Papaveraceæ*) [**48**]. Herbs yielding a sticky juice (*latex*), which is either milky in appearance or else coloured. Leaves alternate and exstipulate. Sepals, two; petals, four. Stamens numerous. The flowers are very conspicuous, and the numerous seeds are albuminous. Poppies are the best-known types, and the latex of one species (*Papaver somniferum*) is the source of opium. The greater celandine (*Chelidonium majus*), a common hedgerow plant, has yellow flowers, and yields an orange-yellow juice.

4. WALLFLOWER ORDER (*Cruciferæ*) [**49**]. In this large and important order the leaves are alternate and exstipulate. There are four sepals in two whorls, four petals arranged in the form of a cross, six stamens (four long and two short), and two carpels. The ovary is divided into two cavities by a partition growing out from the edges of the fused carpels. Seeds exalbuminous. Good examples of the order are wallflower (*Cheiranthus cheiri*) and stocks (*Matthiola*); also many common wild forms, such as shepherd's purse (*Capsella bursa-pastoris*), lady's smock or cuckoo-flower (*Cardamine pratensis*), and charlock (*Brassica sinapistrum*), a noxious weed of which the yellow flowers are seen in cultivated fields. Many species are used as food—*e.g.*, watercress (*Nasturtium officinale*), and garden cress (*Lepidium sativum*), which together with white mustard (*Brassica alba*), constitutes the familiar "small salad" or "mustard and cress." Cultivated radishes are derived from one wild species (*Raphanus raphanistrum*), turnips, swedes, and rape from another (*Brassica campestris*); while ordinary and red cabbage, cauliflower, Brussels sprouts, and savoys, have all been produced by cultivating the wild cabbage (*Brassica oleracea*)

5. VIOLET ORDER (*Violaceæ*) [**50**]. Leaves alternate, with stipules. The flowers are irregular and more or less conspicuous. The flower-leaves are in fives, except the carpels, of which there are three. Violets and pansies (*Viola*) are the best-known plants in the order.

Certain pitcher-plants (*Sarracenia*), yellow corydal (*Corydalis lutea*), the caper-plant (*Capparis*), of which the flower buds are used for caper sauce, rock-rose (*Helianthemum*), mignonette (*Reseda*), and the insect-eating sundews (*Drosera*), belong to other orders of the group.

c. Mallow Group (*Malvales*). The flowers are regular, and the parts of the perianth are in fives. Stamens variable in number, often united by their filaments. Carpels three or more, with the ovary in compartments.

6. MALLOW ORDER (*Malvaceæ*) [**51**]. Leaves alternate, with stipules. The filaments of the numerous stamens are united into a tube, and the carpels are also numerous. Seeds nearly or quite exalbuminous. Well-known examples are marsh-mallow and hollyhock (*Althæa*) mallows (*Malva*), the tree-mallow (*Lavatera*) which grows by the sea, and also the cotton-plant (*Gossypium*).

7. LIME ORDER (*Tiliaceæ*). Mostly trees or

shrubs with alternate stipulate leaves. The corolla is often reduced and inconspicuous. Seeds albuminous.

The lime or linden (*Tilia*) is visited by numerous bees, for though its flowers are not very conspicuous, they are exceedingly fragrant, and produce large quantities of nectar.

The Cocoa-tree (*Theobroma Cacao*) belongs to another order of the group, and so does the tea-plant (*Thea sinensis*).

d. Disk-flower Group (*Disciflorœ*). The chief distinctive feature of this large assemblage of plants is found in the fact that the single whorl of carpels is borne on a swelling of the receptacle, technically known as a "disk." It is in reality a nectary.

8. Flax Order (*Linaceœ*).—Leaves exstipulate. The flowers are regular, with four to five sepals, the same number of petals and stamens (there may be ten of the latter), and three to five carpels united together.

The order is mentioned here because it includes common flax (*Linum usitatissimum*), the bast-fibres of which are used in linen manufacture.

9. Geranium Order (*Geraniaceœ*). The parts of the flower are mostly in 5's, and the carpels are united. The upper part of the pistil is generally beak-shaped. Seeds nearly or quite exalbuminous. The crane's bills (*Geranium*) bear regular flowers, while those of the much-cultivated pelargoniums are more or less irregular, as are the stork's-bills (*Erodium*). Indian cress or "nasturtium" (*Tropœolum*) [33], and balsam (*Impatiens*). The delicate white flowers of wood-sorrel (*Oxalis acetosella*) are regular.

Rue (*Ruta*), oranges and lemons (*Citrus*), holly (*Ilex*), spindle-tree (*Euonymus*), vine (*Vitis*), Virginia creeper (*Ampelopsis*), maple and sycamore (*Acer*), and horse-chestnut (*Hippocastanum*), belong to other orders of the group.

e. Cup-flower Group (*Crateranthece*). The receptacle is either flat or to some extent cup-shaped, so that the flower is more or less perigynous. Sepals and petals in 4's or 5's.

10. Pea Order (*Leguminosœ*). Our native species of this large and important order possess alternate stipulate leaves, and irregular butterfly-shaped flowers [Wistaria, 36]. There are five united sepals and five petals, free except that the limbs of the lowest two are partly united. Stamens ten, with all their filaments united into a tube, or the uppermost one free. There is but a single carpel, which ripens into a pod that liberates its seeds by splitting down one side. The seeds are exalbuminous. The order is notable in many ways. Some of the included species do much to give colour to our landscapes, especially gorse (*Ulex europœus*), broom (*Cytisus scoparius*), and the clovers (*Trifolium*). Others are valuable fodder plants, as clovers, vetches, and horse-bean (*Vicia*), while many—*e.g.* pea (*Pisum sativum*), scarlet runner (*Phaseolus multiflorus*), broad bean (*Vicia faba*), and lentil (*Lens esculenta*) are important articles of food.

Exotic members of the order differing in many respects from the types already mentioned are the liquorice plant (*Glycyrrhiza*), indigo (*Indigofera*), and numerous species of acacia [32].

11. Rose Order (*Rosaceœ*) [34 and 52]. Leaves with stipules, and usually alternate. The regular, often conspicuous flowers possess five sepals, five petals, numerous stamens (as a rule), and a variable number of carpels, which may be free or united. Seeds exalbuminous, or nearly so.

This order is also large and very important. Among beautiful species roses (*Rosa*) and hawthorn (*Cratœgus*) are conspicuous, while the following yield edible fruits: plum, apricot, and cherry (*Prunus*), strawberry (*Fragaria*), pear and apple (*Pyrus*), quince (*Cydonia*), medlar (*Mespilus*), and peach (*Amygdalus*).

Saxifrages (*Saxifraga*), gooseberry and currant (*Ribes*), and stone-crop (*Sedum*) belong to other orders of the group.

f. Myrtle Group (*Myrtales*). As in the last group there is a cup-shaped receptacle, but this is in all cases fused to the ovary, which is therefore inferior.

Among familiar plants belonging to orders of the group are willow-herbs (*Epilobium*), evening primrose (*Œnothera*), and fuchsia, with the parts of the flower in 4's, while in the last the sepals are brightly coloured. Other examples are myrtle (*Myrtus*) and the related eucalyptus, which is an important Australian forest tree, and may be nearly 500 feet high. Pomegranate (*Punica*), Brazil nut (*Bertholletia*), and clove (*Eugenia*), of which the flower-buds are used as spice, also belong to this group.

g. Cucumber Group (*Pepones*). Regular flowers, some of which possess stamens and others carpels. Such male and female flowers may occur on the same or on different plants.

Cucumbers, melons, gourds, and allied plants constitute one order (*Cucurbitacea*) of the group, while the common garden plant begonia belongs to another (*Begoniaceœ*).

h. Cactus Group (*Cactales*). Here the leaves are reduced to scales or prickles, and their work is taken over by the thick green stems, which assume the most extraordinary forms. The very numerous flower-leaves are spirally arranged.

i. Parsnip and Carrot Group (*Umbellales*). The small flowers are epigynous and there is a fleshy nectary on the top of the inferior ovary. Seeds albuminous.

12. Parsnip and Carrot Order (*Umbelliferœ*) [53]. The small flowers are arranged in *umbels*—*i.e.* a number of flower-stalks radiate from the same point, and in this way conspicuousness is brought about, so that many insects are attracted.

A number of useful species belong to the order, such as caraway (*Carum carui*), carrot (*Daucus carota*), parsnip (*Pastinaca sativa*), parsley (*Petroselinum sativum*), coriander (*Coriandrum sativum*), and celery (*Apium graveolens*). Some species are very poisonous, especially the hemlock (*Conium maculatum*).

Ivy (*Hedera helix*) and cornel or dogwood (*Cornus sanguinea*) belong to other orders of the group.

Sub-Class 2. (*Monopetalœ*). The flowers possess both calyx and corolla. Petals united.

k. Madder and Honeysuckle Group (*Caprifoliales*). Foliage-leaves opposite, with stipules. Ovary inferior. Seeds albuminous.

Among plants belonging to this group are the following: Madder (*Rubia tinctorum*) once important as the source of a red dye-stuff, goose-grass or cleavers (*Galium aparine*), a common hedgerow plant, the coffee plant (*Coffea arabica*), cinchona, from the bark of which quinine is obtained, and honeysuckle (*Lonicera*), with conspicuous irregular fragrant flowers.

l. Star-flower Group (*Asterales*). Leaves exstipulate. The flowers are small, but being aggregated together in large numbers, are conspicuous. They are epigynous, and the inferior ovary contains but one ovule.

13. DANDELION ORDER (*Compositæ*). [54]. What looks at first sight like a single flower in a member of this order—*e.g.*, dandelion, really consists of a number of very small flowers (*florets*) crowded together into what is technically known as a "head," round which is a protective covering of bracts, liable to be mistaken for a calyx. The parts of the flower are in 5's, except the carpels, of which two are present, these being united. The stamens are attached to the corolla, and their anthers are united into a tube which surrounds the style. The calyx is greatly reduced, and often converted into a crown of hairs. Seeds exalbuminous. Among the most conspicuous of the very numerous plants belonging to this large and dominant order are sunflower (*Helianthus annuus*), aster, dahlia, cineraria, and chrysanthemum. Other well-known forms are dandelion (*Taraxacum officinale*), daisy (*Bellis perennis*), ox-eye daisy (*Chrysanthemum leucanthemum*), thistles, groundsel (*Senecio vulgaris*), and colt's-foot (*Tussilago farfara*). Valerian (*Valeriana*), teasel (*Dipsacus*), and scabious (*Scabiosa*) belong to other orders of the group.

m. Heath Group (*Ericales*). Flowers more or less conspicuous. Carpels three to ten, united. Ovary superior. Seeds albuminous.

14. HEATH ORDER (*Ericaceæ*). Evergreens with exstipulate leaves. Flowers nearly or quite regular. Ovules numerous. This order greatly contributes to the beauty of our moorland landscapes, for it includes heather (*Calluna vulgaris*), and the various kinds of heath or bell-heather (*Erica*). Azaleas [31] and rhododendrons are near relatives of these.

n. Primrose Group (*Primulales*). Flowers regular, with five stamens opposite the petals, to which they are attached. Carpels five, united. The superior ovary contains but a single cavity, and the ovules are attached to a projection on the floor of this. Seeds albuminous.

15. PRIMULACEÆ [55]. Leaves exstipulate. Flowers commonly conspicuous, with parts in 5's. Primrose (*Primula vulgaris*), cowslip (*P. veris*), and sow-bread (*Cyclamen*) are the most familiar members of the order.

Sea-thrift (*Armeria*) belongs to a related order.

o. Tube-flower Group (*Tubifloræ*). Sepals and petals 4–5, stamens 2–5, pistil of 2–5 united carpels. The superior ovary contains two or more compartments.

16. POTATO ORDER (*Solanaceæ*) [56]. Flowers regular, with parts usually in 5's, except the carpels, of which there are two. Numerous small albuminous seeds. The potato plant (*Solanum tuberosum*) and tobacco plant (*Nicotiana*) are of obvious importance, and valuable drugs are obtained from the virulently poisonous henbane (*Hyoscyamus niger*), deadly nightshade (*Atropa belladonna*), and thorn-apple (*Datura stramonium*). Petunias also belong here.

17. FOXGLOVE ORDER (*Scrophulariaceæ*) [57]. Flowers generally irregular and stamens four, though these are sometimes two or five. There are two compartments in the ovary. Seeds as in last order. The mulleins (*Verbascum*) possess nearly regular flowers (with five stamens), generally of yellow colour, and arranged in tall handsome spikes. The conspicuous flowers of foxglove (*Digitalis purpurea*) are arranged along one side of the main axis: the plant is exceedingly poisonous. The little blue speedwells (*Veronica*) possess but four petals and two stamens. Toadflax (*Linaria vulgaris*) and snapdragon (*Antirrhinum*) have irregular flowers of remarkable shape, which have to be forced open by visiting bees.

18. DEAD-NETTLE ORDER (*Labiatæ*). Leaves exstipulate and usually opposite. Stems four-sided. Flowers markedly irregular, with five sepals, five petals, four stamens (usually), and two united carpels. The ovary is deeply divided into four lobes, each of which contains an ovule. Seeds exalbuminous. The white and purple dead-nettles (*Lamium album* and *purpureum*), and ground-ivy (*Nepeta glechoma*) are common types. Many members of the order are aromatic, and yield essential oils. Among these may be mentioned mint (*Mentha*), sage (*Salvia*) [38], thyme (*Thymus*), marjoram (*Origanum*), and basil (*Ocimum*).

Gentians (*Gentiana*), periwinkle (*Apocynum*), convolvulus, forget-me-not (*Myosotis*), wild plantain (*Plantago*), verbena, gloxinia [37], ash (*Fraxinus*), and jessamine (*Jasminum*), belong to other orders of this extensive group.

SUB-CLASS 3. *Incompletæ*.—This is a large and somewhat heterogeneous assemblage of plants in which the flowers, as a rule, either possess no perianth at all, or one consisting of a single whorl of flower-leaves.

p. Central-seeded Group (*Centrospermæ*). Regular flowers, with superior ovary containing but one compartment, in the centre of which is a projection to which the ovules are attached.

19. PINK ORDER (*Caryophyllaceæ*) [59]. Leaves opposite. Contrary to the general rule for the sub-class, the flowers possess both calyx and corolla. Numerous small albuminous seeds. Common examples are pinks and carnations (*Dianthus*), campions (*Lychnis*), and chickweed (*Stellaria media*).

Pepper (*Piper*), docks (*Rumex*), beet (*Beta*), and nettle (*Urtica*), belong to other orders of the group.

q. Green-flowered Group (*Viridifloræ*). Small green regular flowers, with one or two carpels. The superior ovary contains a single ovule. The following belong to various orders of the group: Fig (*Ficus carica*), india-rubber plant (*F. elastica*), hop (*Humulus lupulus*),

hemp (*Cannabis sativa*), bread-fruit (*Artocarpus*), mulberry (*Morus*), and elm (*Ulmus*).

r. Catkin-bearing Group (*Amentales*) [60]. Shrubs or trees with flowers in catkins or heads. The stamens and carpels are in separate flowers, the male and female flowers being on the same or different plants. The perianth is usually wanting, for in most cases there are no insect visitors. The following are common examples of the group: Poplar (*Populus*), willow (*Salix*), oak (*Quercus*), beech (*Fagus*), hazel (*Corylus*), hornbeam (*Carpinus*), birch (*Betula*), alder (*Alnus*), walnut (*Juglans*), and chestnut (*Castanea*).

SEED-PLANTS. CLASS 2. [Monocotyledons.]

s. Lily Group (*Liliiflorœ*). The flowers are regular, with parts in three's, and the carpels are united. In most cases both sepals and petals are either white or brightly-coloured. Seeds, albuminous. There is generally a thickened underground stem.

20. LILY ORDER (*Liliaceœ*). Stamens six in number and ovary superior. The order includes many ornamental plants such as lily (*Lilium*) [35], tulip (*Tulipa*), squill (*Scilla*), hyacinth (*Hyacinthus*), lily of the valley (*Convallaria*), and "red-hot poker" (*Kniphofia*). Also asparagus, and the useful but malodorous onion, garlic, leek, and shallot (species of *Allium*). New Zealand flax (*Phormium tenax*) is of considerable economic importance. Nearly all members of the order are herbs, but to this there are exceptions, *e.g.*, yucca, and the dragon-tree (*Dracœna*) of the Canary Islands, which grows to an enormous size, and is very long-lived.

21. RUSH ORDER (*Juncaceœ*). Plants with narrow leaves and small brown inconspicuous flowers resembling those of the last order in structure. Rushes (*Juncus*) and wood-rushes (*Luzula*) are included here.

22. SNOWDROP ORDER (*Amaryllidaceœ*) [61]. As Order 20, but with an inferior ovary. Snowdrop (*Galanthus nivalis*) and daffodil (*Narcissus*), are examples.

23. IRIS ORDER (*Iridaceœ*). As last order, but only three stamens. Iris, crocus, gladiolus, and saffron (*Colchicum*) are good examples.

The pineapple (*Ananassa sativa*) belongs to another order of the group.

t. Banana Group (*Scitamineœ*). Tropical plants with large leaves and irregular flowers, of which the inferior ovary is generally divided into three compartments. The following plants belong to orders of this group. Banana (*Musa sapientum*), plantain (*M. paradisiaca*), ginger (*Zingiber*), Indian-shot (*Canna*), and arrowroot (*Maranta*).

u. Orchid Group (*Gynandrœ*). Flowers irregular and of remarkable form. The stamens are reduced in number and united with the pistil.

24. ORCHID ORDER (*Orchidaceœ*) [39]. This is the second largest order of seed-plants, only being excelled in size by the Compositæ, and including over 8,000 species. There is usually but one stamen. We have a few British orchids, but the headquarters of the order are in the tropics.

v. Aquatic Group (*Fluviales*). Aquatic forms, in which the stamens and carpels are commonly more numerous than in other Monocotyledons. The ovary is usually superior. The following are examples of orders of the group. Water-thyme (*Elodea*), water-soldier (*Stratiotes*), frog-bit (*Hydrocharis*), flowering-rush (*Butomus*), water-plantain (*Alisma*), arrowhead (*Sagittaria*), pond-weed (*Potamogeton*), and sea-grass (*Zostera*).

w. Palm and Arum Group (*Spadiciflorœ*). The stamens and carpels are generally in separate flowers, which are small and crowded together on fleshy axes, and protected by a sheath (*spathe*) that covers them. Ovary superior.

25. PALM ORDER (*Palmaceœ*) [62]. Large woody plants, nearly all of which are tropical. The large leaves commonly form a tuft on the top of a long cylindrical stem. The flowers are inconspicuous. Stamens six; carpels, three, united. Seeds albuminous, and not more than three in number. Two familiar and useful species are the coco-nut palm (*Cocos nucifera*), which attains a height of about 80 ft., and the date-palm (*Phœnix dactylifera*). Palm-oil, sago, vegetable ivory, and rattan canes are obtained from other members of the order.

26. ARUM ORDER (*Aroideœ*) [63]. Mostly tropical plants, of which the minute flowers are borne on a fleshy, brightly-coloured axis (*spadix*), the spathe surrounding which is often showy. Perhaps the best-known example of the order in this country is the so-called arum-lily (*Richardia æthiopica*), in which the spathe is white and the spadix orange-yellow. Our one native species, cuckoo-pint or "lords and ladies" (*Arum maculatum*) has arrow-shaped leaves blotched with black, a green spathe, and a dark-red spadix.

x. Grass and Sedge Group (*Glumiflorœ*). Inconspicuous flowers in which the perianth is absent or reduced. Groups of them are enclosed in and protected by scaly bracts.

27. GRASS ORDER (*Gramineœ*) [64]. Herbs with hollow-jointed stems (*haulms*), and alternate narrow leaves, the bases of which are in the form of sheaths grasping the stem and split down one side. There is a little membranous outgrowth (*ligule*) at the junction of blade and sheath. Stamens usually three and carpels two, united. The superior ovary contains a single ovule. The seeds are albuminous. All grasses are included here, as well as our cereal crops, *e.g.* wheat (*Triticum vulgare*), barley (*Hordeum sativum*), and oats (*Avena sativa*). The bamboo (*Bambusa*) and sugar-cane (*Saccharum*) are also members of the order.

28. SEDGE ORDER (*Cyperaceœ*) [65]. These differ from grasses in the possession of solid stems, while the leaf has no ligule and its sheath is not split. The members of the order abound in marshy places, and are common on the edges of streams, ponds, and lakes. The papyrus of the ancient Egyptians was prepared from the pith of one species (*Papyrus antiquorum*).

To be continued

MATERIALS OF CONSTRUCTION

Copper, Tin, Lead, Zinc, Aluminium, Bronzes, Brasses, and other Alloys of the above. Solders. The lesser used Metals. Metalloids

By Professor HENRY ADAMS

Copper. The use of copper (*Cuprum*; symbol Cu; atomic weight 63) dates from very early times, probably because it frequently occurs in a native metallic state, either in detached masses, as on the southern shores of Lake Superior, or in veins disseminated through granite, etc., as in Cornwall and Wales. It is too tough to be blasted, and has therefore to be cut into portable blocks by the laborious use of chisels.

There are several ores of copper, as the red and black oxides, the green carbonates, and, most abundant of all, the yellow ore known as copper pyrites, consisting of copper, iron, and sulphur. Grey copper ore is also abundant and contains the same elements together with antimony and arsenic. The smelting of copper ore consists of several processes: (1) Roasting, to expel the arsenic and part of the sulphur and to convert the iron into oxide of iron. (2) Melting, to remove the oxide of iron in combination with silica, leaving a coarse metal consisting chiefly of sulphide of copper. (3) Calcining the coarse metal to remove more of the iron and sulphur. (4) Fusing of the calcined coarse metal to remove the remainder of the iron and produce *fine metal*. (5) Calcining or roasting the fine metal to remove the sulphur and obtain blistered copper. (6) Refining and toughening to purify the copper. In the latter process about six or eight tons of blistered copper are loosely piled upon the hearth of a melting furnace [38 and 39], so that the air may circulate freely through it.

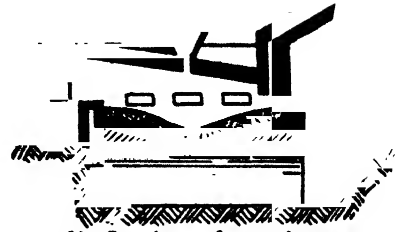
Toughening. The oxygen of the air combines with the remaining sulphur and arsenic to form sulphurous and arsenious acid gases, and with the iron and other metallic impurities to form oxides. In about six hours the metal is melted and the slag formed upon the surface is raked off. The copper is then ready for toughening. To effect this the surface is covered with wood-charcoal, or with pounded anthracite, to protect it from further oxidation, and the molten metal is then stirred with a pole of green wood (usually birch). The end is kept under the surface and carbonic acid gas is disengaged until all the oxygen is driven off. Experience tells the men when the copper has attained its *tough pitch*. If the poling is carried on too long, the copper is called *overpoled*, and is then brittle and of an orange colour, of no use for working as copper, but good for brazing spelter. When the copper is intended to be rolled into sheets, a small quantity of lead is added, and stirring renewed to convert the lead into an oxide which rises to the surface and brings with it the oxides of any foreign metals, and is then skimmed off.

Characteristics of Copper. Copper is well known by its distinctive reddish colour; it is very soft and malleable, is also ductile, and is capable of a high polish. The malleability is increased by heating up to a certain temperature, but when heated to nearly melting point, it becomes very brittle. Advantage is taken of this property in foundries, where copper requires to be broken up to get the right proportions of copper and tin, or other metal, for casting. When hammered and rolled, copper becomes rigid, stiff, and hard. To cure this it is heated in a large chamber with flame passing through it, but as air is present, scale is formed. To get this off it is brushed over with common urine, heated again and dipped in water, when it all comes off clean. When sheet copper is exposed to the atmosphere on roofs, a green protecting film of carbonate of copper is formed, and no further action takes place. The thickness known as 24 B.W.G., weighing one pound per square foot, is generally used and its only disadvantage is its first cost. Being a good conductor of heat, it is used in thicker plates for locomotive fireboxes, but it loses tenacity in proportion to the rise of temperature. In the form of wire it is used for bell pulls and electrical conductors, and in the form of tape, averaging one inch wide and one-eighth of an inch thick, for lightning conductors. It is most largely used, however, alloyed with other metals, a great variety of properties being thereby developed that will be described presently.

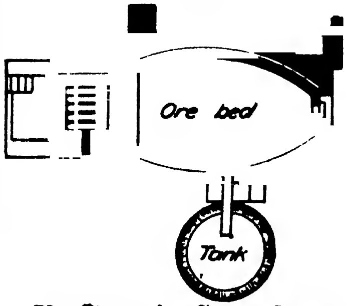
Tin. Tin (*Stannum*; symbol Sn; atomic weight 118) is extracted from an ore called tinstone, consisting of oxide of tin, and found in Cornwall from the most remote times to the present day. It occurs as *mine tin ore* in veins traversing rocks of quartz, granite, or clay-slate, with other metallic impurities, and as *stream tin ore* mixed with mineral matter deposited by torrents in the valleys adjacent to the veins of mine tin ore. The marketable tin is prepared from the raw ore by the following operations: (1) Mechanical preparation of the ore. (2) Calcining or roasting. (3) Washing the roasted ore. (4) Smelting. (5) Refining.

The ore when raised from the mine is roughly freed from earthy matter by washing upon a grating, then broken and picked over to remove copper and iron pyrites, and crushed in a stamping mill [40]. It then goes through further washings on a buddle and other apparatus, where advantage is taken of the high specific gravity of tinstone to separate it from the impurities with which it is associated. The ore is next calcined in a reverberatory furnace with very long horizontal flues in which the oxidised arsenic

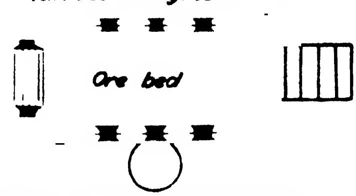
38. Section of refining furnace for copper



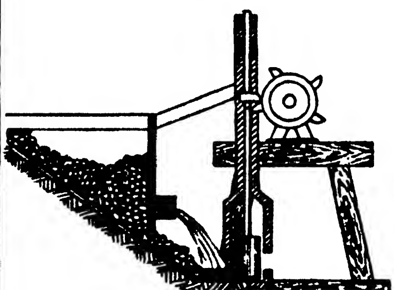
41. Section of reverberatory furnace for galena



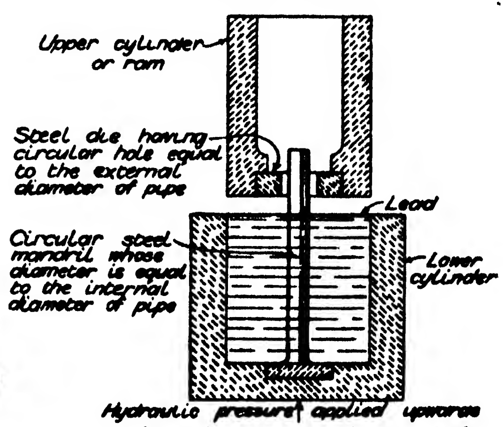
39. Plan of refining furnace for copper



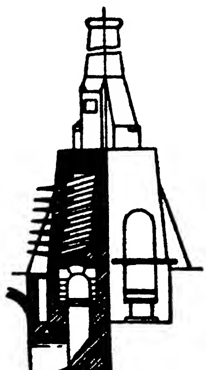
42. Plan of reverberatory furnace for galena



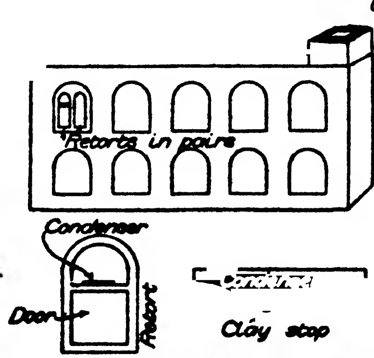
40. Section of stamping mill for tin ore



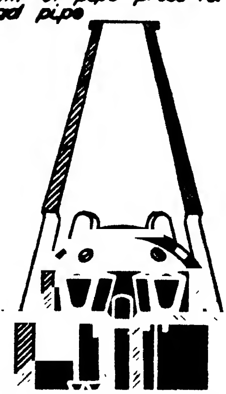
43. Diagram of pipe press for lead pipe



44. Section of Belgian furnace for zinc



45. Arrangement of Silesian furnace for zinc



46. English method of extracting zinc

PROCESSES IN EXTRACTING METALS FROM THEIR ORES

is deposited as white arsenic. Part of the sulphur passes off as sulphurous acid gas and part combines with the copper and oxygen to form sulphate of copper. The roasted tin ore is then stirred in water to dissolve the copper sulphate, and washed on a rack to remove the oxide of iron, leaving *black tin*, which is smelted in a reverberatory furnace with a little lime to form a flux. The flux or slag is raked off the top and the molten tin runs into a pan and afterwards into cast-iron ingot moulds. The ingots of tin so obtained still contain a large proportion of impurities and are refined by operations known as *liquation* and *boiling*. The former consists of melting out the tin from a number of ingots and collecting the purer metal into a *refining basin*. The boiling consists of plunging stakes or logs of wet wood into the molten metal, which is kept hot by a separate fire, the steam given off causing the appearance of boiling and carrying the impurities to the surface in a froth which is skimmed off. It will be noticed that in every operation some of the material remains in a state of considerable impurity, and this being collected, is again passed through the process, so that in time it all comes to a final marketable state.

Tin Plate. Tin is so little affected by exposure to the air or the action of weak acids that it is used as a coating to protect other metals. Tin-plate and block tin are thin sheet-iron plates pickled, annealed, scoured to remove all oxide, and immersed in a cast iron pot containing melted tin covered with three or four inches of tallow; they remain in long enough for the tin to form an alloy with the surfaces of the iron, so that firm adhesion is secured. They are then immersed in molten tin of high purity, brushed and plunged into melted tallow, when the surplus tin runs to the lower edge and is afterwards removed. The plates, after being cleaned with bran, are packed in boxes containing from 100 to 225 sheets. Block tin has not only a thicker coating, but the entire surface is gone over with a polished hammer upon a polished anvil to improve the union between the two metals and stiffen the plate. Copper culinary utensils are very readily coated with tin and are then safe for domestic use; when uncoated, a portion of the copper is liable to be converted into acetate of copper or verdigris, which is dissolved, and the food prepared in such vessels becomes poisonous. Tin has the curious property of creaking when a small bar of it is bent, called the "cry of tin," but it is not used in a natural state except as a lining to lead pipes. It enters largely into alloys.

Lead. Minerals frequently contain lead (*Plumbum*; symbol Pb; atomic weight 206), but practically only one of them is used for the production of this metal—*viz.* Galena or sulphuret of lead (PbS), which has a crystalline form and striking lead-like lustre. It occurs in veins traversing the clay slate in Cornwall, the limestone in Derbyshire and Cumberland, and the granite in Spain, and is also found elsewhere. It usually contains a small portion of silver, which pays for extraction when it reaches two parts per 1000. The ore is broken or crushed, washed, and sorted before passing into a reverberatory furnace [41 and 42]. It there goes through four stages known as the first, second, third, and fourth fires. The fresh ore is put into the furnace while still hot from the previous charge, and a little coal is thrown into the furnace from time to time to keep up a moderate heat to roast the ore, from which some metallic lead runs through the tap-hole. At the end of two hours the furnace damper is raised, more coal is added to increase the temperature, some lime is thrown on the oxide and sulphate of lead upon the hearth, and the melted lead runs out freely. After about an hour the temperature is still further raised for another hour, the slags being spread over the hearth and more lime added. In the final stage the furnace is raised to its highest temperature, the metal run out on one side, and the slag is raked out on the other, leaving the furnace ready for a new charge of ore. The collected metal goes next to an improving furnace, which is a reverberatory furnace with a low arch, whence it is run into an iron pot and transferred to pig moulds. Foreign lead is re-melted in a large copper pan and run into half-round troughs, each containing one hundredweight, to form pig-lead.

Characteristics of Lead. Metallic lead is a bluish grey, with a lustre which is bright when freshly cut, but rapidly tarnishes on exposure to the air, is very soft, can be cut with wood-working tools, but clogs the file, is easily indented, very malleable, and only feebly ductile. Surfaces freshly cut can be welded at ordinary temperatures by simply pressing them firmly together.

When lead is melted in presence of air a greyish powder of sub-oxide is formed on the surface. If stirred vigorously for some time a yellow powder of protoxide of lead (PbO_2) will be formed, called massicot or litharge. Flint glass is composed of yellow oxide of lead, silica, and potash. Lead in large proportion gives great brilliancy to the glass, and the so-called paste gems are thus made. If the heating be further prolonged red lead will be produced. The reduction of oxide of lead—*i.e.* the removal of the oxygen—is very easy; it is only necessary to melt it in contact with charcoal, coal, or coke dust ($2\,PbO + C = 2\,Pb + CO_2$).

Sheet Lead. Sheet lead may be cast in sheets 16 to 18 ft. long, 6 ft. wide, and about ⅛ in. thick, by melting pig-lead and pouring it on to a level sand-bed on a wooden bench, and sweeping off the surplus with a "strike." It is, however, usually made by casting a thick block weighing 4 to 6 tons and passing it under metal rollers until it is reduced to the thickness required. The sheets are from 24 ft. to 36 ft. long and 5 ft. to 8 ft. wide, the finished thickness varying from $\frac{1}{20}$ in. to $\frac{1}{16}$ in. thick, but generally known by the weight in pounds per foot super, say 3 lb. to 10 lb. It is much used in roof work, 4 lb. or 5 lb. lead for aprons, flashings, and soakers, 5 lb. to 7 lb. lead for hips and ridges, 6 lb. to 8 lb. lead for gutters and flats, and wherever it is liable to be walked upon, 7 lb. to 8 lb. for soil pipes. The weight in pounds per foot super multiplied by

0·017 will give the thickness in decimals of an inch.

How Lead Pipes are Made. Lead pipes are made in a hydraulic press, one form of which consists of a steel cylinder [43], containing molten lead from which the scum has been removed and having a rod equal to the required inside diameter of pipe standing up in the centre. This is raised by water pressure to meet a fixed ram of the same diameter as the inside of the cylinder, and with a die in the bottom having a hole equal to the outside diameter of pipe. When the lead has just set, the cylinder containing it is forced upwards, and the lead squirting through the annular space in the bottom of ram forms a continuous pipe, which is coiled on a wooden drum. Lead pipes must not be used for the conveyance of soft water, although the water itself does not act upon the lead; it holds in solution some of the oxygen of the air, and this converts a portion of lead into oxide of lead, which is very poisonous, and accumulates in the human system, giving rise to colic and paralysis. Hard water does not have the same effect, as some of the carbonates contained are deposited on the lead and protect it.

Zinc. Zinc (symbol Zn.; atomic weight 65) is found to a limited extent in England as zinc sulphide, called *zinc blende* or *black jack*, and *zinc carbonate* or *calamine*. The blende is stamped to powder and washed to free it from earthy matters, calcined in a reverberatory furnace with a double hearth, being first roasted on the cooler portion near the chimney and then on the hotter part near the furnace. The roasted ore used to be distilled with coke in fire clay crucibles arranged round a furnace like a glass furnace [46]. Each crucible had a pipe leading from the bottom, in which the zinc was condensed and passed into a receiver. A considerable quantity of oxide was carried down with the zinc, and the whole was re-melted in an iron pot, skimmed, and cast into flat cakes or ingots of spelter. The Belgian process is, however, now generally employed in England. The mixed ore and coal are put into fire-clay cylinders of about 8 in. diameter and 3 ft. long, closed at one end. From 40 to 80 of these cylinders are ranged in a furnace [44] in tiers like gas retorts. The carbon of the coal unites with the oxide of the zinc and escapes as carbonic oxide, leaving the metallic zinc to come off as a dense vapour, which is condensed in cast iron conical tubes, from which it is raked out into a large iron ladle. The zinc is then skimmed from dross and cast into ingots of 70 lb. to 80 lb. each. In the Silesian process the calcined calamine is distilled with coal or coke in large retorts or muffles arranged in a furnace building as in 45.

Characteristics of Zinc. Zinc is a bluish metal, probably the "kuanos" of Homer, pliable and moderately soft. At a temperature of 200° to 250° F. it is rendered malleable and may be rolled into thin sheets. For this purpose the crude ingots are re-melted and cast into purer ingots of convenient size for rolling and passed between cast iron rolls. Sheet zinc is extensively employed for cheap gutters, rain-water pipes, baths, and roofing, for which it is eminently fitted by its resistance to the action of air and moisture. It soon tarnishes by the formation of a thin film of oxide, which preserves it from further action, but it has one serious defect for roofs, as it blazes fiercely under the action of fire, producing light white flakes of oxide of zinc which form the basis of a paint called zinc-white. The acids in the air of towns act freely upon zinc and corrode it. This is also liable to occur on flat roofs, to which cats have access.

Zinc, like copper, becomes very brittle if worked much with a hammer, but this may be obviated by annealing or heating it and allowing it to cool very gradually. Bronze, however, requires to be cooled quickly to anneal it. If the zinc be heated to just below melting point and cooled gradually it becomes very brittle, so that care has to be taken not to overheat it. Like tin, if bent backwards and forwards, it crackles.

Galvanised Iron. Galvanised iron is sheet iron coated with zinc by immersing it when thoroughly cleansed into melted zinc covered with powdered sal-ammoniac. The term "galvanised" arises from the original process of depositing the zinc on the iron plate by immersing the plates in a solution of sulphate of zinc and connecting them to the wires from the negative pole of a galvanic battery. The plates are generally corrugated to give them stiffness, and go by the name of corrugated iron, frequently used for covering temporary sheds. This material is ill adapted for use in towns, as the acids of the atmosphere attack the zinc, exposing the iron and allowing it to rust into holes. It is generally supposed that zinc is very light, but it is only seemingly light from the thinness of the sheets. Its weight is practically the same as that of cast iron.

Aluminium. Aluminium (symbol Al; atomic weight 27), discovered by Wöhler in 1828, is probably the most abundant of all metals, as it exists in every variety of clay (*silicate of alumina*). It is more easily obtained from some of its ores, such as bauxite. The ground mineral is mixed with soda-ash and heated in a reverberatory furnace, when the soda combines with the silica and alumina, forming silicate of soda and aluminate of soda, the carbonic acid being expelled as gas. The mass, after cooling, is treated with water to dissolve the aluminate of soda, which is then mixed with hydrochloric acid to remove the soda, leaving a gelatinous precipitate of hydrate of alumina. This is mixed to a stiff paste with common salt and charcoal powder, made up into balls the size of a fist, dried, and heated in earthenware cylinders through which chlorine gas is passed. The carbon of the charcoal combines with the oxygen of the alumina and escapes as carbonic oxide gas, while the aluminium unites with the chlorine to form chloride of aluminium; this combines with the salt (*chloride of sodium*) to form a double chloride of aluminium and sodium, which distils over and condenses to a solid mass. It is then mixed with sodium and fluor spar to form a slag to protect the metal, and thrown upon the red-

hot hearth of a reverberatory furnace, which is immediately closed to exclude the air. The sodium abstracts the chlorine and frees the aluminium, which collects in a melted state below the slag. Aluminium is now made at a tenth of its former price, and is coming largely into use for domestic utensils and a great variety of ornamental articles.

Characteristics of Aluminium. It is a white malleable metal about as hard as zinc, and fuses at a somewhat lower temperature than silver. It is extremely light and does not tarnish on exposure to the air. In appearance its colour is about midway between the two metals, zinc and silver. It is used extensively in alloys.

Bronze. Bronze is a mixture of copper and tin in various proportions, say, ten copper to one tin. Gun metal is a bronze with a little zinc in it. The following table gives the principal bronze alloys:

Name.	Copper.	Tin.	Zinc.
Soft gun-metal	16	1	—
Mathematical instruments	12	1	—
Pumps (very tough)	32	3	1
Pump plungers	14	1	1
Small toothed wheels	10	1	—
Locomotive bearings	64	7	1
Engine bearings	112	13	½
Locomotive straps and glands	130	16	1
Admiralty mixture for valves and mountings	90	10	2½
Hard gun-metal for bearings	8	1	—
Bally's metal	32	5	2
G. M. for heavy bearings	32	5	1
Maximum hardness for bearings	5	1	—
Hydraulic valve faces	4	1	—
Tam-tam (Chinese gongs)	4	1	—
Bell metal	3 to 5	1	—
Speculum metal	2	1	—

Other Bronzes. Aluminium bronze consists of 90 parts of copper to 10 of aluminium. Delta metal consists of 53½ parts of copper, ½ part of tin, 41½ parts of zinc, 1 part of lead, 1 part of iron, and ½ part of manganese. Phosphor bronze consists of 82 parts of copper, 10 parts of tin, 7½ parts of lead, ½ part of iron, ½ part of nickel, ½ part of phosphorus.

Brass. Brass is a mixture of copper and zinc in various proportions, say, for high brass, two copper to one zinc, and low brass four copper to one zinc. The terms *higher* and *lower*, applied to brass, express the greater or less quantity of zinc in the composition. The following table gives the principal brass alloys:

Name.	Copper.	Zinc.	Tin.	Lead.
Tough for engine work	100	15	15	—
For turning and fitting	8	1	—	$\frac{1}{16}$
Soft for hammering	7	3	—	—
Yellow brass	2	1	—	—
Stop-cocks and valves	88	10	2	—
Rolling-stock bearings	77	—	8	15
Flanges for brazing	32	1	—	1
Brass for soldering	8	3	—	—
Brass, various	60 to 92	8 to 40	½ to 3	½ to 3
Muntz metal sheathing	3	2	—	—
Do. locomotive tubes	66	33	—	1
Nails for sheathing	87	4	9	—
Statuary bronze	90	5	2	—
Red brass (Tombak)	8 to 10	1	—	—
Red sheet brass (German)	11	2	—	—
Bronze for lamps	27	6	1	1

Antimony. Antimony (*Stibium*; symbol Sb; atomic weight 122) is used in alloys for type founding, and for making antifriction metals. Type metal consists of three to seven parts of lead and one part of antimony. For stereotype metal a little bismuth is added to reduce the temperature of fusion. Hard antifriction metal consists of one part of copper, 50 parts of tin, and five parts of antimony. For soft antifriction metal the copper and tin are omitted and lead is added.

Nickel. Nickel (symbol Ni; atomic weight 59) is also used in alloys, chiefly in the manufacture of German silver and electro plate, consisting of copper, zinc, and nickel. It also enters into the composition of phosphor bronze and a variety of steel.

British Coinage. The bronze coinage consists of 95 parts copper, four parts tin, one part zinc. Three pennies weigh one ounce avoirdupois and a halfpenny is exactly one inch in diameter. It is proposed to use a nickel alloy instead of this mixture, as is done by many continental nations. The silver coinage consists of 7½ parts copper and 92½ parts silver. The gold coinage contains 91⅔ per cent. of pure gold, and the remainder copper. Pure gold is almost as soft as lead, and the addition is for the purpose of making it harder and more fusible.

Fusible Alloys. Alloys containing bismuth are called fusible alloys. According to the proportion used of lead, tin and bismuth, the melting point may be made to vary from 472° F. for bismuth alone to 200° for a mixture of one lead, one tin, and four bismuth. It will be noted that this is lower than the temperature of boiling water.

Solders. These are moderately fusible alloys used for joining metals. Plumbers' fine solder consists of one part of tin to one part of lead. Plumbers' coarse solder, one part of tin to three parts of lead. Tinmen's fine solder, three parts of tin to one part of lead. Tinmen's coarse solder, two parts of tin to one part of lead. Hard spelter for brazing, three parts of copper to one part of zinc. Soft spelter, one part of copper to one part of zinc.

Autogenic soldering consists of directing a flame of hydrogen along the edges of lead plates so as to melt and unite them without the use of solder. This method is chiefly used in joining plates for forming sulphuric acid chambers, as the ordinary solder would be rapidly eaten away by the acid attacking the tin. Sulphuric acid has no action upon lead.

THE LESSER USED METALS

Gold. Gold (*Aurum*; symbol Au; atomic weight 196) is found only in the metallic state, and exists practically in all parts of the world, but in the majority of cases its quantity is too small to pay for its separation. It is mostly disseminated in fragments and branches through quartz rock, but is also found largely in streams and sands, where it has evidently been produced by the crumbling of the rocks containing it, which have been worn away by the action of the water, leaving the gold deposited by reason of its great weight. It is generally extracted by

crushing and washing the auriferous quartz, or washing the sands containing it, the separation being effected by the difference in the specific gravity of the gold and the other matters. It is also obtained by the process of amalgamation with mercury, which dissolves the gold, and other processes are used according to the richness and nature of the matrix in which it occurs. Pure gold is uninfluenced even by strong acids, but can be dissolved by a mixture of nitric and hydrochloric acids. Its permanence arises from its resistance to combination with oxygen and sulphur, and it is only the minuteness of the particles rubbed off in its wear that causes its ultimate disappearance. It is too soft for use in its pure state, and hence for coinage is alloyed with $8\frac{1}{3}$ per cent. of copper. The presence of lead or antimony, even in very minute proportions, renders gold extremely brittle. The fineness or purity of gold is expressed by the number of carats of pure gold in 24 carats of alloy. Pure gold would thus be 24 carats fine and sovereign gold 22 carats fine. This latter is the highest degree of purity used by jewellers and is confined to wedding rings. For other purposes 18 carat gold is generally used, the alloy being gold, silver, and copper. The lowest degree of purity used under the name of gold jewellery is nine carats fine.

Malleability of Gold. Gold is the most malleable metal. It may be extended by beating to 650,000 times its original surface, the average thickness being $\frac{1}{282000}$ of an inch.

Gold leaf is made from a small ingot of pure gold weighing two ounces; this is annealed and hammered until it is reduced to one-sixth of an inch thick, and is then passed between steel rollers and annealed as often as may be necessary until it is formed into a riband weighing only six and a half grains per square inch. It is then cut up into pieces one inch square, which are piled up alternately with pieces of vellum four inches square. The beating is performed with a 16 lb. hammer, having a convex circular face four inches diameter. After various manipulations, and when the gold has been extended to twice the width each way, each leaf is cut into four equal parts of one square inch each. These are now placed between alternate layers of gold-beaters' skin and beaten with a 10 lb. hammer until they are each extended to about four inches square. These are again cut into four equal parts, put between gold-beaters' skin and hammered out with a 7 lb. hammer until they are about three and a half inches square. The gold leaves are then cut to exact size and packed between paper rubbed over with red chalk to prevent sticking, and made up in books of twenty-five. Mechanical power is sometimes substituted for hand labour.

Silver. Silver (*Argentum*; symbol Ag; atomic weight 108) is found in a native metallic state like twigs or branches of silver crystals strung together. It also occurs in combination with sulphur, chlorine, bromine, iodine, and associated with other metals in various ores, such as copper, zinc, and lead. Pure silver is soft and readily tarnished on exposure by reason of its affinity for sulphur in the sulphuretted hydrogen of the atmosphere of houses. Standard silver, as used for the silver coinage, is alloyed with copper to harden it, and a considerable quantity of copper may be added without altering the colour. The hardest alloy contains four silver to one copper. Standard silver is whitened by heating it until the oxygen of the air has converted a little of the copper at the surface into oxide, which is then dissolved by immersion in weak sulphuric acid or by other means, and is brightened by burnishing.

Electro Plating consists of depositing pure silver or other metal upon a baser foundation by means of a galvanic battery. The articles are suspended in a solution of cyanide of silver in cyanide of potassium, by wires connected to the last zinc plate of the battery, and the last copper plate of the battery is connected with silver plates suspended in the silvering liquid. The current from the battery causes the decomposition of the cyanide of silver in the solution, the silver being deposited upon the suspended articles, and the cyanogen set free combines with the silver of the suspended plates, forming fresh cyanide of silver and keeping the solution always at full strength. Simply, the operation consists in the transfer of silver from the suspended plates to the suspended articles through the intervention of the liquid and by means of the electric current.

Silvering on Glass. This may be effected by the precipitation of silver from a solution by chemical agents, and this often occurs accidentally on the interior of test-tubes when testing for silver by reagents, but looking-glasses are "silvered" with an amalgam of tin and quicksilver containing no silver at all.

Mercury or Quicksilver. Mercury or quicksilver (*Hydrargyrum*; symbol Hg; atomic weight 200) comes chiefly from the State of California. It is found also in other parts of the world in its metallic state, and in combination with sulphur as cinnabar. It is obtained from its ore by distillation, and is the only known metal which is liquid at ordinary temperatures. Brought into contact with other metals, it unites with them to form an amalgam, except in the case of iron and platinum, which are not attacked by it.

Mercurial Thermometers. Mercury is extensively used in the construction of thermometers because of its fluidity through a considerable range of temperature, and from its low specific heat, causing it to respond quickly to changes of temperature. It does not adhere to the glass, and hence in a large tube is always rounded on the upper surface, but it is so mobile that it will traverse a very minute tube, as in clinical thermometers, where the expansion of the mercury in the bulb produces a considerable travel, or large scale of movement, in the capillary tube.

Platinum. Platinum (symbol Pt; atomic weight 197) is a very valuable metal, only dating from 1741. It occurs in the metallic state, is very malleable and ductile, and resists the action of heat, oxygen, and acids. Although

very expensive, it is much used for crucibles and evaporating basins, but must not be heated in connection with metals, as it forms an alloy with them very readily. On account of its resistance to corrosion it is used for forming the touch-holes of small arms and cannon. In its finely divided state as spongy platinum it has the property of condensing gases into its pores, which raises its temperature to calorescence, and forms the basis of the self-lighting mechanism for incandescent gas mantles.

Arsenic. Although a metal, arsenic (symbol As; atomic weight 75) is not used in the metallic state. It occurs as an impurity in copper, tin, and zinc ores, and is very poisonous. It occurs in some green pigments, and from this cause old wall papers with green colourings were often very poisonous, but other green colouring matters have now been discovered by which its use is obviated. It renders wrought iron cold-short and hinders welding.

Bismuth. Bismuth (symbol Bi; atomic weight 210) occurs in ores with nickel, cobalt, copper, silver, and arsenic. It has a reddish colour and a highly crystalline appearance, is very brittle, and is only used in its pure state in the construction of thermo-electric piles, composed of alternate bars of bismuth and antimony, which are used as very delicate thermometers by the generation of electric currents. Its chief use is in the formation of fusible alloys.

Manganese. Manganese (symbol Mn; atomic weight 55) is not used alone. In cast iron, where it is always present to a small extent, it tends to produce the white variety. In wrought iron it renders the removal of phosphorus and sulphur more complete in the puddling process, although the puddling is attended with more difficulty. In steel, in small quantities, it increases the tenacity and causes it to weld more freely.

Metalloids. This is the name given to several chemical elements which, although not metals, have some of their characteristics. The following are the principal metalloids.

Carbon. Carbon (symbol C; atomic weight 12) occurs in several well-known but widely diffused forms—as the diamond, charcoal, graphite or blacklead, soot, lampblack, &c. In iron it produces fluidity and in steel hardness, while in copper it produces brittleness. When burnt with a limited supply of oxygen, it forms carbon monoxide, carbonic oxide, or fire-damp (CO), which burns in the presence of more oxygen to form carbon dioxide, carbonic acid, or choke-damp (CO_2). CO is poisonous, but CO_2, although not directly poisonous, will neither support combustion nor life.

Silicon. Silicon (symbol Si; atomic weight 28) occurs as an impurity in wrought iron, and reduces its tenacity more than phosphorus does, acting whether the iron is hot or cold. A small quantity of silicon in steel produces sounder ingots, but it should not exceed ·08 per cent. In combination with oxygen silica is produced, which is the substance of common sand and is largely present in all fire-clays.

Sulphur. Sulphur (symbol S; atomic weight 32) is the pale lemon-yellow crystalline substance, which enters into combination with very many metals to form sulphides and with oxygen to form sulphates. It is also well known in combination with oxygen as sulphur dioxide or sulphurous acid (SO_2), in combination with water as sulphuric acid (H_2SO_4), and in combination with hydrogen to form hydric sulphide, sulphurreted hydrogen, "or rotten egg gas" (SH_2). It is the action of sulphur in the air that tarnishes silver. In combination with iron or steel it causes them to be red-short, but in steel this is somewhat counteracted by the presence of manganese.

Phosphorus. Phosphorus (symbol P; atomic weight 31), in its pure state, is like a semi-transparent crystalline wax, which combines freely with oxygen. It is largely used in one or other of its forms in the manufacture of domestic matches. Its combination with wrought iron causes cold-shortness, or brittleness. In cast iron it increases the hardness and fluidity. In steel it causes brittleness; in copper it increases the tenacity and the fluidity, and renders castings sounder.

Fluorine. Fluorine (symbol F; atomic weight 19) is only of interest because of its intense action. When liberated in any chemical process it immediately attacks the containing vessel. In combination with hydrogen forming hydrofluoric acid (HF), it has the property of dissolving glass and other compounds of silica, and is therefore used for etching on glass.

To be continued

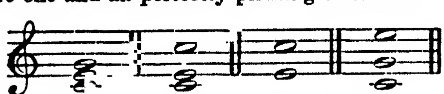
Group 22
MUSIC
3
Continued from page 294

HARMONY: CHORD-MAKING AND MANAGEMENT

The Common Chord; Chord Progression; "Motion" of Parts; Consecutive Fifths and Octaves; Cadences and Sequences; Inversions of Chords

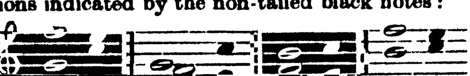
By J. CUTHBERT HADDEN

FOLLOWING the study of intervals comes very naturally an introduction to the study of harmony, since all harmony is founded on the combined use of intervals arranged according to certain laws. For the purpose of this study of harmony we have to distinguish two kinds of interval, consonant and dissonant. When two or more sounds heard together produce an agreeable sensation on the ear, the result is termed *concord*. In that case the intervals are consonant. When the sensation is not so agreeable—when *discord* is produced—the intervals are dissonant. Listening to the notes of a consonant interval or intervals struck together we feel the result to be complete and satisfactory in itself; whereas the dissonances, though not necessarily harsh and repugnant, are felt by the ear to be unsatisfactory and suggestive of other combined intervals to follow. This may be illustrated in a very simple way. Here, for instance, are four consonant combinations which are one and all perfectly pleasing to the ear:



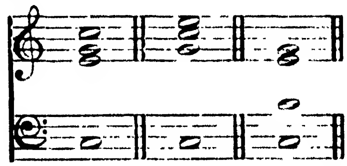
They can be played or sung, each by itself, without any acute desire for something to come after.

On the other hand, such combinations as are shown by the semibreves in the following illustration are altogether unrestful for the ear. They are made up of dissonances, and suggest, if they do not actually demand, the combinations indicated by the non-tailed black notes:

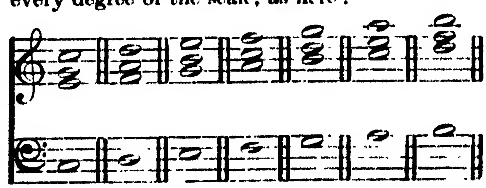


The harmony student, then, must know how to distinguish between the consonant intervals and the dissonant. That, happily, is not difficult. The consonant intervals are the unisons and octaves, the major and minor thirds, the perfect fourths and fifths, and the major and minor sixths; the dissonant intervals are the major and minor seconds, sevenths, and ninths, and all augmented and diminished intervals. A combination of three or more of these intervals is called a *chord*; a *concord* when consonant intervals are only used; a *discord* when dissonant intervals make a constituent part.

Concords and discords are naturally of many kinds, for the combinations which can be produced by the union of diatonic and chromatic intervals are very numerous. But the basis of all possible combinations is the triad or common chord. This consists of a fundamental note as bass, with its third and fifth added. Thus, if we sound the notes C, E, and G together, we have a triad or common chord—the common chord of C. Add the octave of the foundation note (C) and the chord admits of three principal positions:



It is plain that we can build up a chord on every other degree of the scale by the same process of adding a third and fifth above the foundation note. But here we have to mark certain important differences which arise in the structure of chords. Suppose we set down a triad on every degree of the scale, as here:

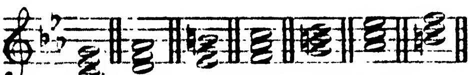


Now look at the lower thirds in these combinations. In the case of the chords on the first, fourth, and fifth degrees, these thirds are major, while those on the second, third, and sixth degrees have minor thirds. The difference is essential; for it divides the chords of the scale into two classes—major chords when the lower third is major; minor chords when it is minor. One chord, that on the seventh of the scale, stands by itself. All the other chords, while they disagree as to their thirds, agree in having a perfect fifth. This chord on the seventh degree is unique in having a minor third and an imperfect fifth, hence it is termed an *imperfect*, sometimes a *diminished, chord*.

Thus, then, of the seven chords of the major scale, three are major, three are minor, and one is imperfect. Naturally the most important of the lot are the three major chords, those upon the tonic, dominant, and subdominant. These are sometimes called the fundamentals of harmony, because by their use alone every note of the scale may be harmonised. Chords, let it be added, are named from their roots according to the degree of the scale that the root is founded upon—as tonic, supertonic, mediant, etc., etc. Thus we speak of the chord C, E, G as the chord of the tonic when the key is C, of E, G♯, B

similarly when the key is E; and so on. As a theorist has it, "it is to the relation of chords to a scale or key that attention must be directed." At the same time we can speak of chords without reference to the key-relationship: the chord of C, of G, of F, and C in whatever key these are found.

The chords of the minor scale demand some special consideration, chiefly on account of the artificially altered notes of that scale. In the major scale, as has been seen, the foundation chords are characteristically major. One would naturally expect that, conversely, the foundation chords of the minor should be minor. But this is not the case. Take an illustration in C minor:



Minor. Imperfect. Augmented. Minor. Major. Major. Imperfect.

Here only two chords, those of the tonic and the subdominant, are minor. The dominant is converted into a major chord by the incidental raising of the seventh note of the scale. The uses of these three chords in their root positions are exactly the same as in the major. The chords on the minor supertonic and on the leading note are imperfect and cannot be used in their root positions. On the raised sixth there can be no common chord, nor on the mediant when the seventh of the scale is raised, though we must recognise it as an augmented triad since it is occasionally used. It must be frankly allowed that the chordal usages of the minor scale present many perplexing problems to the young student. They arise chiefly, if not entirely, from the varied forms in which the minor scale is written and are therefore inevitable. Only as his practice extends, and his theoretical knowledge widens, can the student hope to thoroughly master this branch of his subject.

Thus, then, we have learnt about the constituents of common chords. Now we have to learn something of the way in which these chords are used. For, of course, chords cannot be made to follow each other at pleasure: the *progression* of every note in a succession of chords must be carefully considered. Hence we arrive at the elementary rules of part-writing. When we speak of "parts," we generally mean four voices (treble, alto, tenor, bass) or four instruments. That is the simplest and best method of studying the progression of chords.

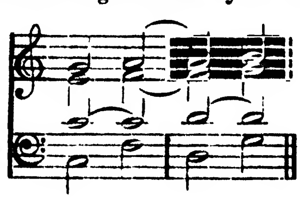
Well, first of all, since concords have but three constituents, we must see which constituent can be "doubled" for four-part writing. The rule is to double the root first. If the context does not allow of that being done, then double the fifth. The third, when it is major, must not be doubled except in special circumstances; nor must it be omitted whether it is major or minor. The third of a chord, remember, is what determines whether the chord is major or minor, and if it is omitted the chord has no definite character. Moreover, it is the third which gives a chord its harmonic life and quality. The fifth may be omitted without detriment; the third never.

This matter of "doubling" having been arranged, we have next to understand how the individual notes of the chord are to be disposed among the various parts. Clearly it would be impossible always to superimpose them in the order of root third and fifth; and indeed there is no restriction about the distribution of the notes of a chord beyond this, that the lower notes should be separated by the largest intervals, and that the diminution of the intervals should be gradual. Look at the following:

(*a*) (*b*) (*c*)

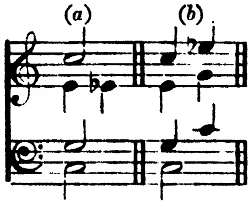
Here we have various arrangements of the chord of C. Those at *a* are perfectly satisfactory; those at *c* less so; those at *b* altogether bad. The essential thing to remember is that in distributing the constituents of a chord there should be no disproportionate hiatus: that the largest intervals should be at the bottom, the smallest at the top. Except in the case of bass and tenor, none of the parts should be separated by an interval exceeding an octave.

We speak next of the connection of the various chords. Here the rule is to choose as far as possible chords which may be connected by one or more notes common to both. Thus the chord of the tonic might be followed by that of the subdominant, because the note C is common to both, by that of the dominant because the G is common. The subdominant, again, might be followed by the supertonic chord because A is a constituent of both; and so on, as here, the common note being indicated by the tie:



Moreover, when two notes of the same name and pitch occur in consecutive chords it is well to keep them in the same part in both chords, as in the above example. This produces a smoothness and a tranquillity not to be obtained otherwise. It is, however, a recommendation rather than a rule, and applies more particularly to the inner parts (alto and tenor): the rule is practically absolute (there are one or two exceptions) when two notes of the same name but of *different pitch* occur in two consecutive chords. In this case the two notes *must* be in the same part, otherwise there is produced what is termed a *false relation*. Thus, if we have E in the alto part of a chord

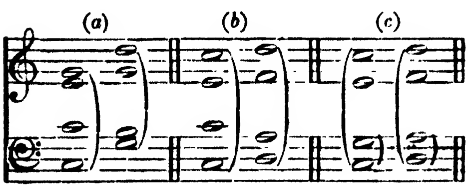
and write E flat in the soprano part of the next chord, the result is a false relation. See the following example, where (*a*) is according to rule and (*b*) is not:



Note that the bad effect of a false relation often remains though a chord intervenes between the chromatic notes.

So much for connecting pairs of chords. Now to consider the general *motion* of the parts. "Motion" is a technical term, representing three separate kinds of movement. We have *similar motion* when two or more parts ascend or descend at the same time; *contrary motion* when one part ascends while the other descends; and *oblique motion* when one part remains stationary while the other ascends or descends. Of the three, contrary motion is preferable, not only because it is most grateful to the ear, but because it is less likely to lead to infractions of the rule as to consecutive fifths and octaves, of which we shall speak presently. Similar motion in all the parts should be avoided if only because of the tame effect produced. A mixture of two or of all three forms of movement will generally give the best result.

Closely connected with this matter of motion is the important rule—one of the most important in part-writing—which forbids two or more perfect fifths, octaves, or unisons between the same two parts, whether by skip or conjunct movement. Here



at *a* we have consecutive fifths between bass and treble; at *b* consecutive octaves between the same parts; at *c* both consecutive fifths and octaves, the first between bass and tenor, the second between bass and treble. In similar motion the effect of such consecutives is especially bad; in contrary motion they are rather less objectionable. To make the parts move in an opposite direction to the bass is one of the surest methods of avoiding them. Of course the student will understand that the forbidden intervals apply only to an actual progression of simultaneous parts. Where there is no melodic movement there is no objection to a repetition of fifths or octaves between any two parts. Thus the following are not regarded as infringing the rule:

Note also that consecutive fifths are not forbidden when one of the fifths is imperfect.

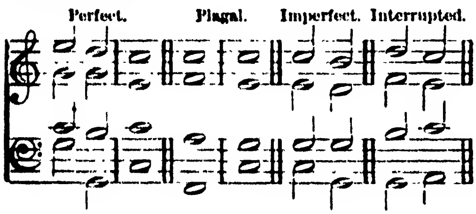
What are called *hidden consecutives* must also be avoided. These are much less easily discovered by the unpractised harmonist, being always, as their name implies, hidden or covered over. The rule is that the extreme parts (treble and bass) are not to proceed by similar motion to an octave, fifth, or unison. Thus, if we write
C, E.
A, E. we are said to produce a "hidden" consecutive octave, because, were the scale notes between in both cases filled in, we should have D going to E in both parts. Similarly we have here a "hidden" fifth

as shown by the filling in with the small-sized crotchets. There are several exceptions to the rule about hidden consecutives, but in all his early work the student is advised to observe rigidly the other rule to which it gives rise, namely, that in the outside parts a perfect concord or unison should be approached by contrary or oblique motion. In regard to all these rules of part-writing it must often be a case of one rule yielding to another—laws of progression to laws of position and *vice versa.* Violations of most rules will be found in the works of the great masters, the good effect produced being sufficient justification. Before the young harmonist thinks of following their example, he should see that his theoretical knowledge is complete. In any case, the rules against consecutive fifths and octaves admit of practically no infringement.

Let us look now at the various kinds of *cadence.* A cadence, in the ordinary use of the term, is the close of a musical sentence. Generally the two last chords determine its character as *perfect* or *imperfect, plagal* or *interrupted.* The perfect cadence, as its name suggests, is the most satisfying, and on that account is used at the end of every composition and generally at the end of every movement. It consists of the major chord of the dominant (a seventh may be added), followed by the tonic chord. The imperfect cadence, in its commonest form, exactly reverses this order of chords: the tonic chord

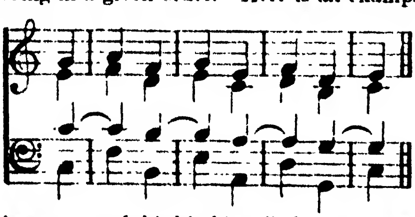
comes first and is followed by the dominant. This cadence is of course never used at the end of a composition, but only at the end of a phrase or section. It "seems almost to ask a question."

In the plagal cadence the determining chords are the sub-dominant and tonic. This cadence is most frequently met with in sacred music, as at the close of Handel's Hallelujah Chorus. The interrupted cadence is something of a contradiction, being "in the strictest sense, not a cadence at all, but the interruption of one by the appearance of some other than the tonic chord, when the progression has been such as to lead to the expectation of a perfect cadence." Interrupted cadences are harmonically of various kinds. The most usual form arises from the progression of the dominant to the sub-mediant chord. All these forms of cadence are simply illustrated here:

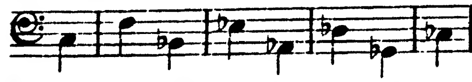


In choosing his cadences the student should aim at securing variety. This is the more necessary in a short composition, where repeated use of the same form of cadence would produce a very monotonous effect.

The subject of *sequences* need not detain us, for the sequence, though frequently beautiful in effect, is of the nature of a mechanical device. It may be defined shortly as a repetition of the same succession of intervals on different degrees of the scale. Thus the melody may alternately rise a second and fall a third, the bass rise a fourth and fall a fifth, the other parts also progressing in a given order. Here is an example:



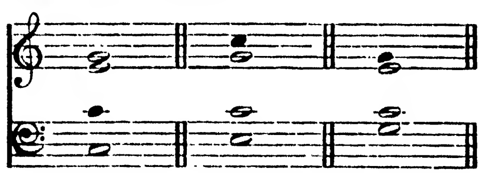
A sequence of this kind is called tonal, because the intervals all belong to the unaltered scale. They are minor or major, perfect or imperfect, just as they present themselves. In the *real* sequence, so called, the respective intervals are exactly alike. Thus, in a real sequence, the above bass part would have to be written thus:



so that every rising fourth and falling fifth should be perfect according to the pattern.

Tonal sequences are much more frequently used than real. When the bass or melody moves sequentially the other parts should do the same, though, for variety's sake, this rule may sometimes be ignored. Sequences are held to justify the infringement of a good many laws of part-writing, the ear being attracted and pleased by the evident *design* of the pattern, and so likely to accept what in an ordinary progression might sound objectionable. Thus a sequence provides almost the only exception to the rule against doubling the leading note.

Up to this point we have dealt with chords solely in their original positions—that is, having the foundation note in the bass. When this note is not in the bass—when it is transferred to an upper part—the chord is said to be *inverted*. A common chord consists, as we know, of three constituents: hence such a chord is capable of two inversions. When the third is put in the lowest part, the chord is in the first inversion; when the fifth, it is in the second inversion. Thus, in the triad of C, we have these three positions, the black note being the doubled note necessary in four parts:



Original Position. First Inversion. Second Inversion.

Note, in passing, that the root of a chord and the bass note are not necessarily the same. In the above illustration the root in all three cases is C; and from this example the student will gather at once that in first inversions the root is a third below the bass note, while in second inversions it is a fifth.

To be continued

Group 11

CIVIL ENGINEERING

3

Continued from page [illegible]

VARIOUS METHODS OF SURVEYING

Including Traversing, Plotting and Levelling, and dealing with the Beam Compass, Planimeter, Pentagraph, Eidograph, Level and Level Staff

By Professor HENRY ROBINSON

Traversing. In our study it has been assumed that the lines of the survey have been tied in by means of chain angles, or that only the main lines have had to be fixed by angular measurement. A common way of carrying out a survey is by *traversing*. For the purposes of this course it is assumed that the earth is a plane surface, and that no corrections for its spherical form are necessary. This assumption for all practical purposes, where the areas surveyed are limited, will cause no appreciable error.

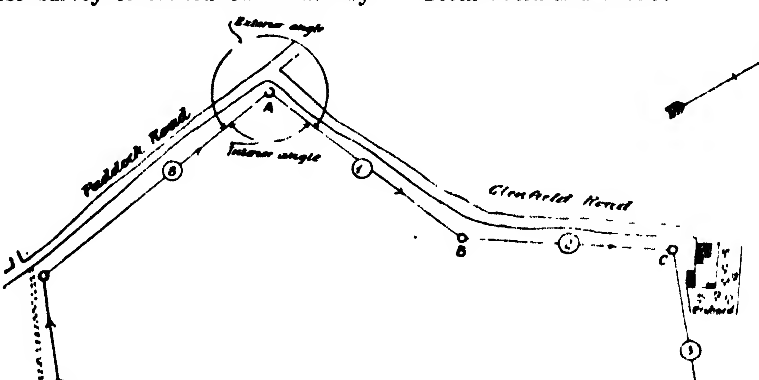
A traverse survey is carried out either by taking the "bearings" of the lines, or the angles between the lines, or by taking both with a theodolite, or some other instrument. The lengths of the lines are measured as in an ordinary chain survey. When practicable the traverse should be "closed," that is, the end of the last line of the traverse should finish at the commencement of the first line, a practice which forms a check on the work. If it be impossible to close the traverse, a series of observations should be taken from the various stations to some well-defined point, preferably within the survey, to form a check. When a traverse is carried out by taking the bearings of the lines only, and not by taking angles, the bearings should be read both forward and backward, to eliminate any chance of error.

As greater accuracy can be attained by reading the angles either external or internal, this method is preferable. One bearing accurately obtained is, however, essential in order to fix the relation of the various lines to the magnetic north. The bearings of the other lines can be calculated after reading the angles between them, as will be explained later. We know from Euclid (Book 1, Prop. 32, Corollary) that in any closed polygon the following obtains:

1. The sum of the interior angles plus four right angles is equal to twice as many right angles as the figure has sides.

From which is deduced:

2. The sum of the exterior angles minus four right angles is equal to twice as many right angles as the figure has sides. From this it will be seen that if the angles (either exterior or interior) of a closed traverse are read, they may be checked by calculation.



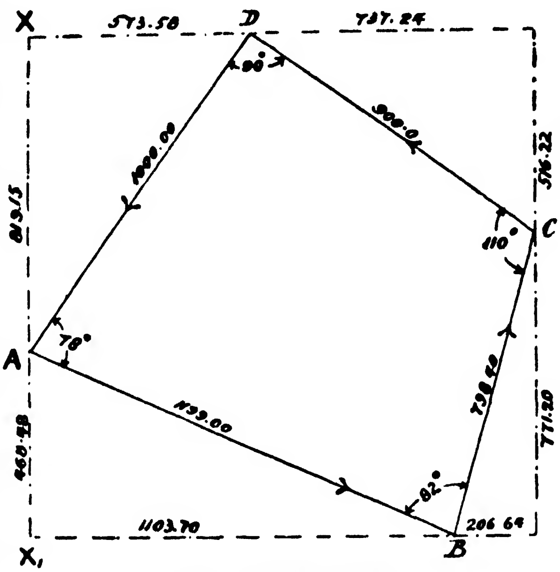
21. TRAVERSE SURVEY

When it is intended to carry out a traverse, it is necessary to adopt some system of reading the angles to avoid errors due to first taking an internal angle, and at another time an external angle, as, although they may have been properly noted, it would be necessary to employ some calculation in order to see whether the traverse was correctly carried out by the calculation of the sum of the angles as previously explained. A good method is always to set the instrument on the backward station first, and then to read on to the forward station (from left to right). If this is done, the rule that is given later for

calculating the bearings of lines from the angles between them will always obtain. The illustration [21] shows a survey carried out by traversing.

A Survey by Traversing. The figure is shown as "closed," although it frequently happens that on starting a traverse the closing line will not be set out until nearing the completion of the work. The method of making this survey was as follows. Ranging poles were set up at the most convenient places, as shown on the illustration by the small circles at the points where the lines join each other. The instrument was then set up at the beginning (A) of line 1, and the forward bearing of AB taken (as explained when dealing with the theodolite), and the exterior angle read. The instrument was then removed and the line chained, the offsets being taken in the usual manner.

This having been completed, the instrument was set up at B, the end of the line, and the backward bearing (BA) of line 1 was obtained. Line 2 was then set out, and a pole put up at C, when the exterior angle ABC was read. This proceeding was continued until the survey had been completed. The direction in which the lines were chained is indicated on the illustration by arrow heads.



22. TRAVERSE SURVEY

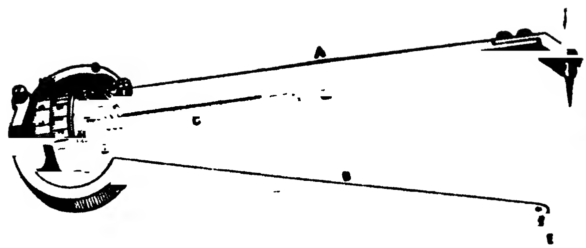
Method by the Bearings alone. As previously explained, this survey could have been completed by means of the bearings alone. The method adopted must depend on the degree of accuracy required.

If the accurate bearing of one line is known, the bearings of all the other lines can be calculated by the following rule, provided that the instrument is first sighted on the back station in reading the angles between the lines. The result of this is to give the external, or internal, angles according to the direction in which the chaining takes place. The bearing will, of course, vary by 180°, depending upon whether it is read backwards or forwards. In any case, the bearing is taken in the same direction as the chainage.

The bearing of any line may be calculated with regard to the bearing of any other line, the angle between them (whether external or internal) being known, in the following way: To the known bearing, add the angle between the side to which it refers; and to the next side, if the sum be less than 180°, add 180° to it; the result is the bearing of the line required. If the sum be more than 180°, deduct 180° from it, and if the remainder be still more than 360° deduct 360° from it; the result is the bearing of

Stations	Distances	Inward Angles	Theodolite Bearings	Reduced Bearings	Single Traverse				Total Traverse	
					N	S	E	W		
1	2	3	4	5	6	7	8	9	10	11
A										
B	1199.0	78°.. 0'	113°.. 0'	67°.. 0' S.E		468.48	1103.70		468.48 S	1103.7 E
C	798.4	82°. 0'	15°.. 0'	15°.0' N.E	771.2		206.64		302.72 N	1310.34 E
D	900.0	110°.. 0'	305°.. 0'	55°.0' N.W	516.22			737.24	818.94 N	573.10 E
A	1000.0	90°.. 0'	215°.. 0'	35°.0' S.W		819.15		573.50	0.21 S. Error	0.48 W Error
					1287.42	1287.63	1310.34	1310.82		
						1287.42		1310.34		
					Error	= 0.21		0.48 = Error		

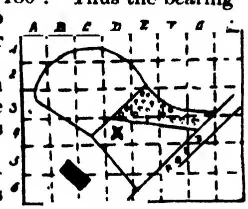
23. REDUCTION BOOK



25. PLANIMETER

the line required. As an example, we may assume the theodolite set up at A [22], and the direction of chaining to be from A towards B. The bearing of the first line AB is taken and its length chained. The interior angle between it and the last line DA is taken. The theodolite is transferred to B, and the angle ABC is observed. The bearing of BC is obtained as follows:

Bearing $AB = 113° 0'$. Angle $ABC = 82° 0'$. Their sum $= 195° 0'$. Then, as already explained, $195° 0' - 180° 0' = 15° 0'$, which is the bearing of BC. As another example, supposing that the traverse was chained the reverse way, the angles read would be exterior angles, and the bearings would differ by 180°. Thus the bearing CB would $= 195° 0'$. To this add the exterior angle $CBA = 360° - 82° = 278°$. The sum would, therefore, be $195° + 278° = 473°$. As before, $473° - 180° = 293°$, which is the bearing of BA, and equals $113° + 180° = 293°$. By the above method the angles all round the survey are observed, and the lengths of the lines chained. It now remains to be shown how these are to be plotted.

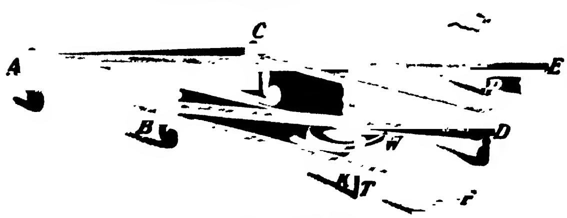


PLAN A

"Northings and Southings" Method. A common method for plotting is by the Protractor. A more accurate way is by means of what is known as *Northings and Southings*, or *Latitude and Departure*. By this method, as will be shown later, the field book is worked out first, and any errors detected before the plotting commences. We know, from trigonometry, that in any right-angled triangle

$$\text{Sine} = \frac{\text{Perpendicular}}{\text{Hypothenuse}}$$

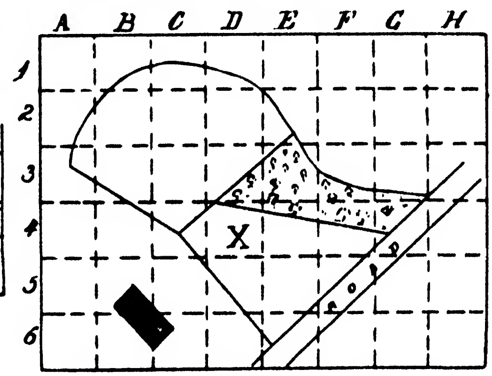
$$\text{Cosine} = \frac{\text{Base}}{\text{Hypothenuse}}$$



26. PENTAGRAPH

Referring again to **22**, if there be any line, AB, of known length, making an angle $X_1 AB$ with any line XX_1, it is possible to calculate the distances AX_1 and X_1B so that by scaling off AX_1 and drawing a perpendicular X_1B to XX_1, and making it equal to the calculated length, the position of B may be fixed by scaling alone. Thus $\frac{X_1A}{AB} = \cos X_1AB$, and therefore $X_1A = AB \cos X_1AB$. Similarly $X_1B = AB \sin X_1AB$. In a traverse survey the bearings (calculated or observed) are the positions of the lines with regard to the North, and may be anything up to 360°.

For the purposes of plotting, it is required to get the actual angle made with a line running North and South (X_1X). This is termed the *Reduced Bearing*, and is used to calculate the distances for fixing the lines on the survey. "Reduced Bearings" may be calculated from the *actual* bearings as follows:



PLAN B

24. ENLARGEMENT OF PLANS

For bearings less than 90° take the bearing direct; for bearings greater than 90° and less than 180°, take 180° − the bearing; for bearings greater than 180° and less than 270°, take bearing − 180°; for bearings greater than 270°, and less than 360°, take 360° − the bearing.

From the above rule it will be found that our reduced bearings are always less than 90°, and therefore the sines and cosines can be obtained from an ordinary set of mathematical tables.

Plotting. In plotting the work, first draw the line XX_1 being the North and South, or *meridian* line. Upon this line a point A is fixed, being the commencement of the survey, and is called the *origin* point. The distances from point to point measured along, or parallel to, this line XX_1 are called the differences of "*latitude*," or *northings* and *southings*, according to their direction. The distances perpendicular to the line are called the *departure*, or

eastings and westings, according to their direction. These directions are obtained from the actual bearings, and are as follows:

0° to 90° = N. and E.
90° to 180° = S. and E.
180° to 270° = S. and W.
270° to 360° = N. and W.

Figure 23 is an example of the *Reduction Book* completed for this case. Referring to this in conjunction with 22, an illustration will be given to show how this book is made up. The bearing of AB is 113° 0′, which is S. and E. The "reduced bearing" is therefore 180° − 113° = 67°, and is entered in column 5, with its sign S.E. The length of AB is 1199, and 1199 cos 67° = 468·48, and 1199 sin 67° = 1103·70. These distances are entered in columns 7 and 8, plotted as shown, and the point B fixed. The next bearing is 15° and, as explained, this bearing, being less than 90°, is the reduced bearing, and is N. and E. The distances are calculated as before (the measured distance of BC being 798·4). As this direction is N. and the previous one was S., the difference of the amounts must be obtained in order to get the actual distance from the origin, and is entered in column 10 (302·72 N.).

The departure is a still further easting, and must be added to the previous reading to get the total distance, and is entered in column 11 (1310·34). The last two columns of the reduction book enable the errors to be observed. If the angles check by calculation, the total error, if any, is in the chaining. The distances are shown on 22, as are the total distances from point to point.

After the fieldwork for a survey has been completed, the work has to be plotted. The scale for plotting must depend on the purpose of the survey. A convenient scale for small surveys is one chain to the inch, but this is too large for extensive surveys. The three scales of the Ordnance Survey are $\frac{1}{2500}$ (or what is termed the 25-inch ordnance), the 6 in. and the 1 in. being 6 in. and 1 in. to the mile respectively.

The Beam Compass. The first thing that has to be done is to plot the survey lines. If of any length this is done with the aid of the *Beam Compass*, by means of which arcs of circles are struck representing the lengths of the various lines from their respective points, and the intersections of these arcs give the points to which the lines have to be ruled. When these survey lines are all plotted and checked, the offsets from the various points of the lines have to be drawn at right angles to the lines. This is best done by means of an *offset scale*, which is a small portion of the main scale (usually 12 in. long). The 12 in. main scale is laid along the line, and the smaller offset scale is moved along it (of course, at right angles), and the various points are pricked off and afterwards joined up. It is often necessary to take out areas when the survey has been plotted. The most convenient method is by means of a "Planimeter," one form of which is as follows:

Amsler's Planimeter. This Planimeter [25], when ready for use, as in the diagram, rests upon three points, D, E, F. These are respectively: first a point of the circumference of the divided wheel D; secondly, a point of the tracer F at the end of the arm A; thirdly, a point E at the end of the other arm B, which is kept fixed during the time of operation.

Place the point E at a convenient distance from the figure to be measured, so that the tracer F may traverse the entire periphery of the figure; but if the figure is too large to allow this, it can be subdivided by drawing straight lines through it, and the contents of the several parts computed separately and added together. Then place the point of the tracer on any convenient starting-point in the periphery. When the instrument is thus adjusted, read off the division on the horizontal disc C, also that on the perpendicular wheel and vernier, H. Suppose that the horizontal disc gives 3, and the vertical wheel gives 905, namely 90 on the wheel and 5 on the vernier, this reading must be put down thus, 3·905. Then carry the tracing point round the figure in the direction of the hands of a watch; and when the whole circuit has been made, observe the reading again. Suppose them 5·763, then subtract the former reading from the latter, the result will be 1·858; multiply this by 10, and you get the contents of the figure in square inches, namely 18·58. Notice must be taken whether the disc C has made an entire circuit, if so, 10 must be added for every revolution to the whole number. Thus, if the disc had gone once round, the second reading would have been 15·763; if twice round, 25·763, and so on.

Scaling an Area. In the event of it being necessary to take out the area by scaling alone, the plot must first be divided up into convenient forms, as for instance, into triangles. In the case of a field surrounded by irregular or curved fences, it will first be necessary to reduce them to straight lines. This can be done by the eye on the "give and take" principle. The area of a triangle is found by multiplying the base by half the perpendicular line drawn from the base to the apex of the triangle. If the three sides of a triangle are known, the following formula will give the area:

$$\text{Area} = \sqrt{s \times (s-a) \times (s-b) \times (s-c)}$$

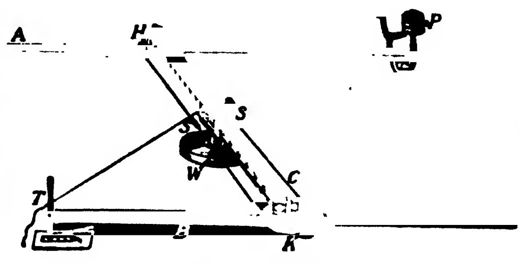
where $s = \frac{a+b+c}{2}$; a, b, and c being the length of the respective sides.

Reduction and Enlargement by Squares. Plans may be enlarged or reduced by means of squares. The method is simple and accurate if carefully carried out. The plan (A) to be enlarged [24] is divided into squares of suitable size. Having decided on the size of the enlargement (B), divide a clean sheet of paper into squares, the size of which must be according to the scale of the enlargement. Then each square on the plan (A) will be represented by a larger square on the clean paper.

The figures, lines, etc., contained by the squares on plan A must be carefully measured

and reproduced in their respective squares on plan *B*. Each square can be numbered as shown on the figure, the cross on the square *D*4 being an example. For reducing plans rapidly the *Pentagraph* and *Eidograph* are used.

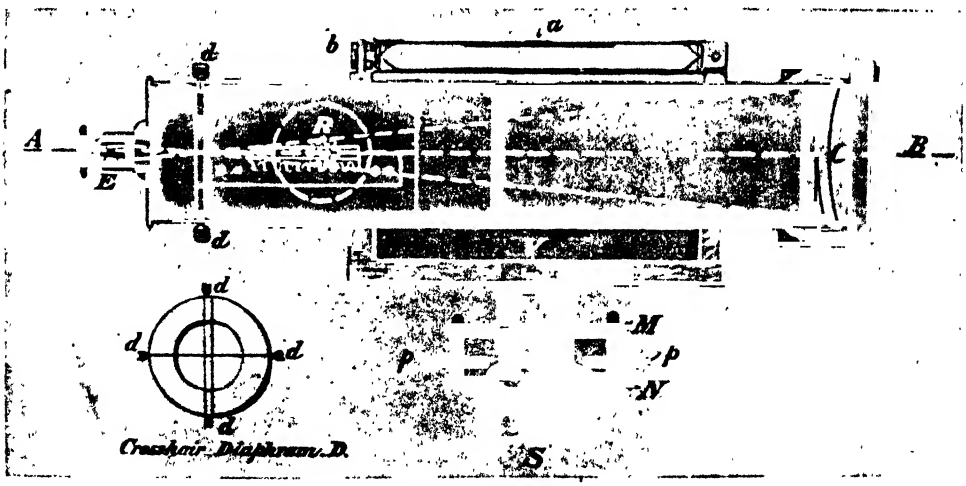
The Pentagraph. This instrument [26] is made from 12 in. to 4 ft. in length, and consists of four bars, two long and two short. The long bars, *AE* and *AF*, are jointed at the point *A*. The short bars, *BD* and *CD*, are jointed at the point *D*, the other ends being attached to the long bars at the points *B* and *C*. This arrangement of jointing produces parallel motion in the instrument. The whole instrument pivots round a weighted centre (*W*) (which is the fulcrum), the bars being supported at intervals by ivory wheels to allow free motion when at work. The pencil, tracer *P*, and the weighted centre *W*, are attached to the bars by tubes which the bar *BD*, the pencil on the bar *AF*, the tracer on the bar *AE*. If it be required to reduce a plan to one-third of its size, place the slide on each divided bar to the division marked ⅓, the pencil being on the bar *BD*, the fulcrum on the bar *AF*, and the tracer on the bar *AE*.



27. EIDOGRAPH

Enlargements should be made by the method of squares, but may be made with the pentagraph, by interchanging the pencil and tracer. As any error is magnified according to the scale to which the enlargement is being made, it is not usual to employ the pentagraph where accuracy is required. The pencil can be raised or lowered as desired, by means of a silk cord provided for the purpose.

The Eidograph. This instrument [27] is used for a purpose similar to that of the pentagraph, but its construction is different. It consists of three bars or arms, *A*, *B*, and *C*,



28. THE LEVEL

enable them to be interchanged, as will be explained later.

The bars *AF* and *BD* are marked off into a number of divisions, and are provided with slides which can be moved to any required division on their respective bars, and are held in position by the clamps *K*. As a general rule, the following instructions should be observed.

On the graduated bars which carry the slides proportioned to the fulcrum and pencil there are usually 21 divisions. Those numbered ½, ⅓, to $\frac{1}{12}$ are to be used with the fulcrum on the bar *AF*, the tracer on the bar *AE*, and the pencil on the bar *BD*. The other fractions, ⅔, ¾, ⅘, and on to $\frac{11}{12}$, are used with the fulcrum on

working on a pivot or fulcrum, *W*. The centre bar *C* has a grooved pulley at each end (*H* and *K*) round which a steel band passes. Any movement of one pulley is transmitted by the band to the other pulley, thus producing the parallel motion. To these pulleys are attached square tubes through which the bars *A* and *B* are passed, clamps being provided to hold them in their required positions. All the bars are graduated, and have verniers to enable the arms of the instrument to be set to their proper positions.

To set the instrument for the reduction of a plan to any required proportion, take the sum and the difference of the fractional terms; then

as the sum is to the difference, so is 100 to the number which is required, and to which the arms and centre bar must be set. For example, to reduce a plan one-third—

$$3 + 1 = 4;\quad 3 - 1 = 2.$$

Then as $4 : 2 :: 100 : x$ (number required)

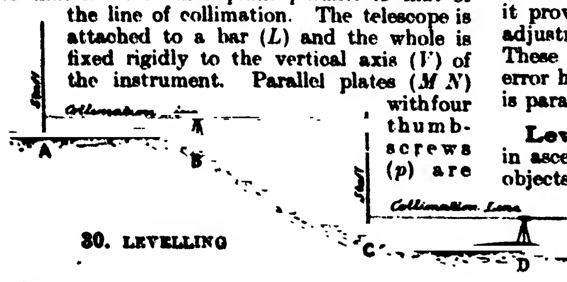
$$\therefore\ x = 50.$$

Then the arm carrying the tracer is lengthened and set to its division, 50. The centre bar is set at its division 50 (on the pencil side of its zero), and the pencil arm is shortened and set to its 50 division. For enlarging a plan the pencil and tracer must be reversed, but as with the pentagraph, all errors are magnified, and the instrument should not be used for enlargement.

The only adjustment which may be put out is the parallelism of the arms *A* and *B*. This is corrected by placing all the verniers to zero, and the arms at right angles to the centre bar *C*. Make a mark with the tracer and the pencil points, turn the instrument half round. The tracer point should fall into the mark of the pencil, and the pencil point into the tracer mark. Should this not occur, adjust by means of the screws (*S*) on the steel band until coincidence takes place.

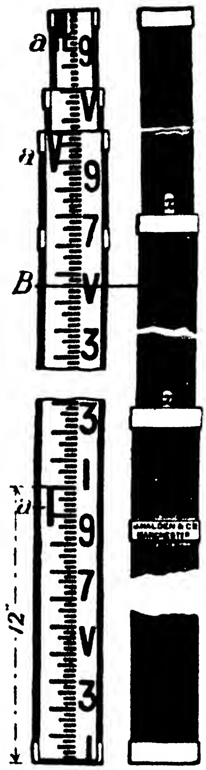
The Level. There are two forms of levels used in ordinary practice, being the "Y" and the *Dumpy*. With the former the telescope is supported in "Y's" (from which it can be removed and reversed in position), fitted to either end of a straight bar, one end being hinged and the other provided with a screw with nuts, by means of which the position of the telescope can be adjusted with reference to the vertical axis.

The *Dumpy* is similar to the "Y" level, but the bar and supports are rigidly fixed to the vertical axis. The illustration [28] shows a dumpy level. The body of the telescope is constructed of a pair of tubes (fitting truly cylindrical and straight) that slide in and out freely, being operated by a rack and pinion (*R*) enabling the image obtained by the objective (*O*) to be focussed by the eyepiece (*E*). The telescope is fitted with a diaphragm (*D*) carrying crosshairs capable of adjustment by the screws (*d*) provided for the purpose. This enables the plane of the horizontal crosshair to be brought to coincide with the plane of the line of collimation (*AB*), which is the central horizontal axis of the telescope. A spirit level is attached to the top of the telescope and a screw (*b*) with locknuts is provided to enable the bubble to be adjusted so that it works in a plane parallel to that of the line of collimation. The telescope is attached to a bar (*L*) and the whole is fixed rigidly to the vertical axis (*V*) of the instrument. Parallel plates (*M N*) with four thumb-screws (*p*) are provided to enable the instrument to be set level. The whole instrument is attached by a screw socket (*S*) to a tripod.



30. LEVELLING

To prepare the instrument for working, first set it firmly on the ground, approximately levelling it with the eye, and the lower of the parallel plates, then turn the telescope over two of the screws (*p*) and simultaneously turn them inwards or outwards, according to the travel of the bubble. By this operation the bubble is brought to a central position in its tube. Then turn the telescope over the other two screws, manipulating them as already explained until the bubble is again central. These operations must be repeated until the bubble remains central whatever the position of the telescope.



29. LEVEL STAFF

Adjustments. The adjustment for the bubble of the spirit level is made by altering the locknuts and screws(*b*). Should the bubble be out of centre, tighten or loosen the screw till the error has been reduced by half, re-level the instrument by the parallel screws (*p*) as previously explained. Should any error still remain, repeat the operations until the bubble is central.

Next adjust the line of collimation so that it is parallel with the plane of the bubble. This adjustment may be effected by means of the collimation screws (*d*). These raise or lower the diaphragm *D*, which carries the crosshairs.

Set the instrument up on fairly level ground, midway between two pegs about three chains apart. Take readings on a staff placed first at one peg, and then at the other. These readings give the difference of level of the two pegs. Next set the instrument up nearer one staff than the other, and again take readings. Should any error be found between the readings, taken when the level was midway between the points, and when it was closer to one than the other, it proves that the line of collimation requires adjustment by raising or lowering the diaphragm. These operations must be continued until the error has been eliminated, then the line of sight is parallel to the axis of the bubble.

Levelling. The art of levelling consists in ascertaining the differences in the heights of objects. In this country the Ordnance Survey Department has determined the level of points all over the country, which are called *Bench Marks* (O.B.M.). Their positions are shown on the Survey maps

and on the spot by a symbol in the form of an arrow. Their values are given in terms of the approximate mean tide level at Liverpool, which is taken as the datum line. The heights of the various points on the ground are determined by taking readings with the level on to a graduated staff, which we will now describe.

The Level Staff. The level staff [29] is generally made 14 feet long, being divided into three parts which telescope into each other. When closed up the staff is about five feet long. To prevent inaccurate records being taken by the staff not being properly extended, spring catches (x) are fixed to the joints of the staff. These catches, when locked, prevent any further movement. The staff is divided up into feet and $\frac{1}{100}$ of a foot. The left-hand figures lettered (a) are in red and represent feet, the right-hand figures are black and represent $\frac{1}{10}$ foot or 0·10, the smallest subdivisions being $\frac{1}{100}$ foot, or 0·01. Taking an example: The crosshair of the level cuts the staff at BB, so that the reading is 4·45, as the red figure five (for feet) is above this point, and the black five (for tenths) is just above it. The staff holder has to be careful in his work. The staff must be held quite vertical, and to do this on sidelong ground a plumb bob is sometimes used. If the staff be held out of truth laterally, it can be detected by the vertical wires in the level. To ensure the staff being held vertically, a simple plan is to move the staff slowly backwards and forwards, and the lowest reading that is got by the intersection of the horizontal wire of the level will be the correct one to book.

Survey of Heathcote's Estate August 18 1905

Back Sight	Intermediate	Fore Sight	Rise	Fall	Red: Level	Distance	REMARKS
9·30					155·98		O B.M on SE Corner of "The Views"
	11·60			2 30	153 68	(0 00)	Beginning of Line (1) & (17·40) on line (2)
	7 20		4·40		158·08	1·00	
4·71		6·37	0·83		158 91	1 50	
5 18		3 95	0·76		159·67	1 75	
5·62		4 54	0 64		160 31	1 99	
7·60		2 75	3 07		163 38	2 34	Centre of Road (Wood Lane)
	1 54		6 06		169 44	2 49	
12 63		1 99		0·45	168·99	3 11	
	8·94		3 69		172 68	4·70	
9 85		1 62	7 32		180 00	5 30	
10 78		0 70	9 15		189 15	(7 00)	Line (10) crossed
6·61		0 16	10 62		199·77	6·50	
		1 66	4 95		204 72	(7 81)	End of line (1) at (20 30) on line (4)
72 48 23·74 48 74		23 74	51 59 2 75 48 74	2 75	204 72 155 98 48 74		

31. LEVEL FIELD BOOK [REDUCED]—"RISE AND FALL" METHOD

In choosing the place in which to hold the staff a firm spot is taken, and it is well to have a small piece of slate to place on the ground, for the staff to rest on and prevent its sinking into the ground. It also fixes the point where one reading has been taken, and ensures the staff being held at the same spot for the next reading. The purpose of levelling may be to obtain the level of one point with reference to that of another without any direct measurement to connect the two. This is frequently the case when it is desired to check points already set out, and it is termed *flying levels*. The route taken to obtain these should be one that involves the least amount of levelling between the points. In all levelling operations it is essential that the work should be checked, either by finishing up on a bench mark whose level is known, or else by returning to the starting-point, when the last reading, when reduced, should give the same level as that entered in the field book at starting. On the other hand, if it be necessary to plot an accurate section of the ground, it becomes necessary to chain between the points, and to take the various levels of points on the chain line as the measuring proceeds.

The Operation of Levelling. In commencing operations the level is set up at some convenient place where may be obtained a good view of the first point, which will be a bench mark, whose level is known. The position selected must also give a good view of the direction in which it is intended to proceed. The level having been set up, the staff is held on the bench mark, and the position where the horizontal wire cuts the staff is noted, and the reading booked in the *Back Sight* column. The staff is then moved forward, and held in the new position, and the reading taken, and entered up in the *Fore Sight* column.

The difference of these two readings will give the difference in the level of the bench mark and that of the ground where the staff was held in its new position. The level must now be shifted (the staff, however, remaining) and set up in its next position; a reading to the staff is then taken and entered as a back sight. The

reason for this will be apparent on referring to the illustration [30].

The level having been set up at *B*, a reading is taken on the staff at *A*, the ground level at which point is known, and this is a *back sight*. The staff is then shifted to *C*, and a reading at this point is taken, this being a *fore sight*. The difference of these two readings fixes the level of *C* with regard to *A*. If then the level be moved to another point *D* (the staff remaining at *C*) a reading can be taken to *C* (which is now known), and the staff can then be moved, the position of the level being now fixed with regard to *C*, and another position of the staff can be arranged.

Intermediate Readings. In the event of the levelling being required for some particular line of route (as, for instance, for the centre line of a railway), to enable the section of the ground to be plotted, it will probably be necessary to take a number of readings with the level set up in one position. Then, as before, the first reading at starting, taken after the level has been set up in a new position, is entered as a back sight, and any *intermediate* readings, with the level in the same position, are entered in the column provided for that purpose in the field book.

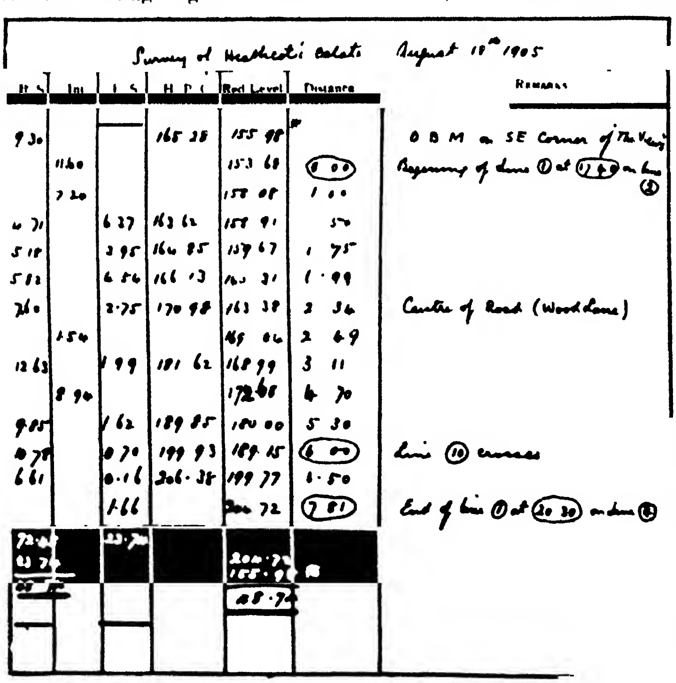
Rise and Fall. Figure 31 is a page of a level field book kept on what is known as the *Rise and Fall* method. Referring to this example, it will be seen that the first reading 9·30 is a back sight; the staff was then held at the beginning of the section line, and an intermediate reading taken of 11·60. As this reading is greater than the first one, it is obvious that the ground must have been lower, so the difference of these two readings is entered up in the *fall* column, and is subtracted from the reduced level of the first point, giving a reduced level of the ground at the new point of 153·68.

It must be remembered that when the following reading is greater than the previous one, it is a *fall;* the difference must be entered in the column provided for that purpose, and subtracted from the previous reduced level. When the following reading is less than the previous one, it is a *rise*. The difference must be entered in the *rise* column, and the amount added to the previous reduced level.

In order to check the page, to see that no errors have been made, the difference of the sums of the back sights and of the fore sights must equal the difference of the sums of the rises and falls, and these two differences must equal the differences of the reduced levels at the commencement and the end of the page. On reference to the example it will be seen that these amounts equal 48·74. Another way of keeping the field book is that known as the *Collimation* method, or H.P.C. (Highest Plane of Collimation).

The Collimation Method. A book kept in this way is shown in 32. The back sight is added to the reduced level of the first point. This gives the reduced level of the collimation line of the telescope. All other readings are subtracted from this, until the level is shifted, and another back sight is taken; this is added to the reduced level of the point at which it is taken, and all other readings are subtracted as before. This method of keeping the book is more rapid than the "Rise and Fall" method, because, to keep the book checked in the field, it is necessary only to deal with the back sights and fore sights, the intermediates being ignored, unless they are necessary for establishing any particular point.

Care, however, must be taken in reducing the intermediate levels, as there is no check on them for arithmetical errors. If at the end of a page of levels the last reading is an intermediate, it must be entered as a fore sight, and on turning the page, the same reading entered as a back sight on the top of the new page. The distance column is the same in both methods, and is used for putting in the various chainages. When it is necessary to take cross sections on lines at right angles to the main section line, poles are ranged out at right angles to the left and right of the line. These are



Survey of Heathcote Estate August 10th 1905

B S	Int	F S	H P C	Red Level	Distance	Remarks
9 30			165 28	155 98		O B M on SE Corner of The V[illegible]
	11 60			153 68	0 00	Beginning of line 1 at 17 49 on line 2
	7 20			158 08	1 00	
6 71		6 37	163 62	158 91	50	
5 18		3 95	164 85	159 67	1 75	
5 82		6 56	166 13	160 31	1·99	
7 60		2·75	170 98	163 38	2 36	Centre of Road (Wood Lane)
	1 54			169 06	2 69	
12 63		1 99	181 62	168 99	3 11	
	8 90			172 60	4 70	
9 85		1 62	189 85	180 00	5 30	
10 78		0 70	199 93	189 15	6 00	Line 10 crosses
6 61		0·16	206·38	199 77	1·50	
		1·66		204 72	7 81	End of line 1 at 20 30 on line 2
72·4[illegible]		23·7[illegible]		204·72		
23 7[illegible]				155·98		
48 [illegible]				48·74		

32. LEVEL FIELD BOOK [REDUCED]—"H P.C." METHOD

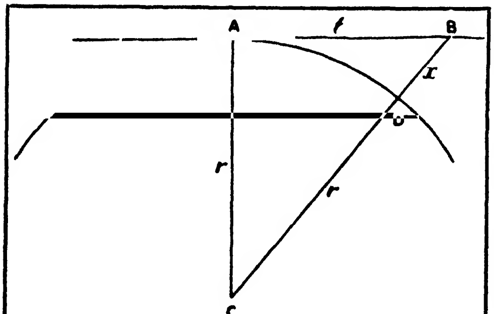
chained and the levels taken at the various chain points. Figure 83 shows how the book is kept. It will be seen that symbols are placed against the various chain points to show at which side of the section the levels have been taken.

Curvature. In the preceding notes it has been assumed that the surface of the earth is horizontal, and that the readings on the staff obtained by the bisection of the collimation line of the level are the true ones. This is practically so for ordinary purposes. Where, however, extremely accurate work has to be done, and where long readings have to be taken, some correction is necessary to allow for the curved surface of the earth.

Survey of Heathcote's Estate — Aug. 30 1905

B.S	Int.	F.S	H.P.C	Red. Level	Distance	Remarks
6·74			162·74	156·00		O.B.M. on N.E corner of Viaduct
	6·00			156·74	4·72	on line 7 Cross Section 1
	4·15			158·59	0·50	┐ Side of Bell Lane
	4·11			158·63	0·70	┐ Centre of " "
	4·14			158·60	0·99	┐ Side of " "
	5·69			157·05	1·74	┐
	6·41			156·33	2·00	┐ Centre of foot path
	7·04			155·70	2·75	┐
	6·81			155·93	4·00	┐
	4·30			158·44	0·25	┌
	4·91			157·83	0·90	┌
	5·71			157·03	1·35	┌
	6·04			156·70	2·10	┌
	6·90			155·84	2·89	┌
	6·74			156·00	3·41	┌
	7·18			155·56	4·05	┌ Side of ditch
	8·10			154·64	4·12	┌ Centre " "
		7·26		155·48	4·20	┌ Side " "
6·74		7·26		* 156·00		
		6·74		155·48		
		0·52		0·52		

83. LEVEL FIELD BOOK—CROSS SECTION



$BD = x$ = ERROR DUE TO CURVATURE

$AC = DC = r$ = RADIUS OF EARTH

AB TAKEN $= AD = l$

$AC^2 + AB^2 = BC^2$

I.E. $r^2 + l^2 = (r+x)^2$

$= r^2 + 2rx + x^2$

$\therefore\ l^2 = x(2r+x)$

DISREGARDING x IN $2r+x$

$l^2 = 2rx \qquad \therefore\ x = \dfrac{l^2}{2r}$

MEAN DIAMETER OF EARTH = 7916 MILES

84. CURVATURE

The true figure of the earth is spheroidal, but for the purpose of correction for curvature it is assumed to be a sphere, the mean diameter of which is approximately 7916 miles.

Refraction. This correction for curvature is partly neutralised by what is known as "Refraction," due to the atmosphere. No absolute value can be laid down for this, as it must vary according to climatic conditions. A good practical rule is to take it equal to one-sixth that due to curvature. In any case, the error due to curvature and refraction is eliminated if the distances of the back sights and fore sights from the level are made *equal*. At distances not exceeding 10 chains the error is so small as to be negligible.

Care must also be taken to ensure the staff being held vertical and on firm ground. This caution applies also to the position chosen for setting up the instrument. Great care must be taken in reading the staff, as individual errors can only be determined by independent checking.

When the reduced levels of bench marks are being used, too much reliance must not be placed on the accuracy of the value given them, and independent levels should be taken between them to confirm their values. It is also useful in all operations to make temporary bench marks, by reading on to some well-defined points at intervals on the route, thus preventing the necessity of going back to the original starting point in case of errors.

To be continued

THE ROOM FOR BRAINS IN INDUSTRY

Some Openings for Men with Ideas. Simple Problems which the Inventive may Solve. Channels by which Old Enterprises may Develop and New Ones Arise

By ERNEST A. BRYANT

HAVING considered some of the achievements of men of ideas, it may be profitable to glance at a few of the more obvious avenues of progress for the benefit of the inventor and the community at large. We shall consider larger schemes in their place; here we shall merely direct attention to some of the minutiæ of our daily wants.

Sparks from Steam-engines. We must all bow to the dictum of the philosophers who tell us that we cannot summon an idea to birth. But the history of mechanical invention teaches us that demand is not uncommonly followed by the production of the thing desired. The Nasmyth hammer, like the many ingenious appliances with which Sir John Aird built his great bridges, came into existence to meet the urgent need of the hour. There must be many Nasmyths, many Airds, in the world to-day. Certainly there remains abundant scope for the exercise of their genius.

Does it not seem incredible that man, who can take the raw iron out of the earth and fashion it into a mighty engine capable of drawing hundreds of tons at the rate of sixty miles and upwards per hour, cannot devise the contrivance necessary to arrest and extinguish the sparks which arise from the funnel of the locomotive? Experiments are in progress while this is being written, but the solution does not seem to be yet at hand. Since the first locomotive was created there has been a constant menace from fire to properties adjoining railway lines. The New Zealand Government, more practical than others, offered years ago a bonus of £3,000 for the production of this contrivance. That offer still, apparently, holds good.

The Full Value of Coal. There are, of course, many larger problems in the same field. The man has yet to arise who will teach us the means to extract full value from the coal we burn. It has been computed that while it took thirty years for 100,000 men to build the Pyramid of Cheops, we have each year to win from the earth a bulk of coal sufficient in dimensions to build two hundred of such pyramids. And six-sevenths of that coal is wasted. Edison tells us that, properly used, a bucketful of coal should drive an express from London to Manchester, and a few tons send a steamer across the ocean. So long, however, as we permit practically the whole of the energy in our fuel to escape as waste, so long must we go on burning tons where pounds should suffice; and so long must we expect to see the atmosphere of our great cities dulled and deadened by the pall of smoke arising from their myriad furnaces.

The question of smoke-consumption is another which claims attention. Invention after invention has been recorded at the Patent Office, but still our industrial centres lie grimy and hideous beneath their black mantles; and London fogs, with coal smoke as the dominant constituent, represent each year a loss of many millions sterling to the community, to say nothing of the sacrifice of life involved. Who shall deliver us from the thraldom of the fog for which London is notorious? Sir Oliver Lodge has in mind the germs of a great invention to this end, but whether his duties in other fields of activity will permit him to work it out is greatly to be doubted.

Lights in Tunnels. Every omnibus conductor has now his little portable electric lamp—a contrivance which fifty years ago would have been deemed an impossibility. Is it too much to hope that some day a man of ideas will give us a light upon a bigger plan which will pierce the fog, if not dispel it, as we take our way by train, by motor, or by steamer? Experimental investigation is tending towards this desirable consummation; there is ample time for the right man yet to make up his mind to be first to arrive—and do so.

Some little time ago a railway worker discovered a method of economising coal while developing a greater head of steam upon the engine he drove. He was fortunate enough to find a sympathetic board of directors who put his scheme at once into operation. A good many years earlier a man of a like cast of mind published particulars of a scheme for lighting tunnels upon railways. His plan was for an installation of electric lamps, which would be automatically kindled the moment the flange of the wheels came in contact with a certain mechanism. When the train passed out of the tunnel, the lamps would be automatically extinguished. It was pronounced by experts simple and feasible, but we still ride, often enough, in lampless trains, through pitch-black tunnels.

Little Things to be Invented. The lighting and ventilation of tunnels offer fields worthy the attention of the inventor. The desire to gain more leisure for play induced a youth to fix the first automatic valve upon an engine; an act of which he thought nothing, but which revolutionised the whole science of steam engineering. Perhaps some genius, held up in an unlighted tunnel, and so debarred from reading his SELF-EDUCATOR, will be inspired to solve the problem; as Edison was driven by want of light to invent the incandescent lamp.

So many things the world needs, that instead of pausing to marvel at what has already been

accomplished, we must wonder that so much has been left undone. We plough and reap by machinery, we lay bricks and make matches by machinery; yet we have to paper our walls by hand, just as they always have been papered since this method of decoration was first adopted. Who that has had a breakdown on a bicycle or motor-car has not yearned for a "monkey-wrench" which could be adjusted in an instant? Why, as domestic servants are able to sweep carpets by simple little mechanical sweepers, should they not be able to scrub a floor as easily and well? Such a machine would save infinite labour, and, incidentally, prevent many cases of "housemaid's knee." There are many excellent fountain pens on the market. We want one still better; one which can be filled with ease, and which will not soil our hands and clothes, and make disfiguring blots by overflow of ink.

The New Typewriter. Handwriting will soon become the pastime of the writer of private letters. We want simpler, cheaper typewriters. Typewriters cost to-day practically as much as they cost when first invented, yielding an enormous profit to those that have the monopoly. The man with genius for the task will give us a machine for which the paper need not be changed every few minutes; for which the "carriage" has not to be returned by hand; and, most important of all, so easy of manipulation that the nerves of the operator, and those of the people about him, may be spared the irritation and strain which the clatter and rattle of the present noisy machines cause. We want a typewriter which shall be practically silent in operation and shall not "jar" the hands and arms of the typist. There is a world-wide market for a machine of this description.

Baths for Every House. Our forefathers were not extravagant in the direction of baths; they left that to the "heathen" East, where cleanliness is next to godliness—is, in fact, an essential preliminary to worship. We of the present generation have not made a sufficiently material advance in the provision for the wherewithal for ablutions to entitle us to make any boast. The poor man returning from his dirty, perhaps noisome, toil, if he need a bath, must take it in what he calls the "houseplace"—*i.e.* the general living room, or go unbathed. An attempt has been made to introduce a bath into cottages by sinking it beneath a detachable floor. Human ingenuity should not be exhausted by this effort. No plans for the building of cottages should be passed which omit a full-sized bath. The question of water supply may be a serious one; we need some simple little reservoir in which every cottager may conserve a proportion of the rain-water which now runs to waste down his drains.

The Need of the Dentist. Dentistry is a much more ancient art than some of its professors realise. They knew how to extract and "stop" diseased teeth in ancient Assyria, Egypt, Phœnicia; and they made artificial teeth three thousand years ago. Then men forgot all they had learned, and hundreds of years were to elapse before dentistry became exalted out of the keeping of barber and clown. Even now, it is only in its infancy. Men with many degrees would feel highly aggrieved if their patients told them frankly what they thought of their work. After all the labour and study which dentists have devoted to their profession, it remains a fact that while their work is of the highest importance to the health of their fellows, it is carried out at a great cost in suffering to the patient. Given the assistance of a good anæsthetist, any clumsy fellow can extract the tooth of a healthy patient; it is the preventive dentist, so to speak, who renders us the greatest service. And his methods are barbarous. The "stopping" of teeth is the most painful operation, the most trying to the nerves to which a sensitive person has to submit. The call is for the man who can drill and fill a tooth as painlessly as he can extract another under gas; and who can furnish a filling which shall be not so expensive as gold, yet capable of withstanding the disintegrating action of saliva.

The Mechanical Side of Books. In the book world fortune awaits the man with ideas. Reference is made, not to authorship, but to the mechanical side of production. Paper, covers, and method of binding are all open to attack. At present we have not a paper which will satisfactorily reproduce a photographic block unless the surface be so highly burnished as to make reading intolerable, or so heavily charged with clay as to make the book weigh pounds instead of as many ounces. What is wanted is a good, light paper, with a smooth surface which will reproduce pictures equally well with letterpress. For covers, a substitute is needed for the strawboard or millboard now commonly in use. As to binding, there are two avenues open to the inventor. The simpler one is to find a way of stitching the periodicals, so that they may open out flat, instead of, as is now the case, shutting when released for a moment by the hand, as if actuated by a spring. The one evil of modern magazines is the way in which their pages have to be wired together.

Book-binding by Machine. There is a larger problem in the binding of books. If machinery can convert a pig into sausages; produce boots from strips of leather; turn out matches ready-made and boxed; set up the type and print a paper at the rate of 50,000 an hour—if machinery can do all this and a thousand other wonderful things, why cannot it also stitch the pages of a book and fasten on its covers? There is no other reason than that the necessary machine has not yet been devised. "Impossible," says the man who has not given thought to the project. "Preposterous," they said when Faraday was toying with the needles which were to give us the electric telegraph. "Madness! Impossible for a steam-engine to work except upon a solid stationary base," declared the President of the Royal Society, when the principle of the first steamboat was explained to him. For long machine builders wanted a machine which would uproot potatoes, "top" and tie them up in sacks, and for long they declared

such a machine impossible. But a family of Yorkshire farmers have made such a machine—out of scrap-iron, beaten into shape in their own little forge. So that those who look for a machine with which to bind a book need not wholly despair.

Many men have made fortunes from boots. Not all have deserved their gains. Man must be shod, so submits to the style and fit imposed. But we are no better off in the matter of comfort than were our forefathers of long ago; indeed, we do not fare so well. It is still the case that our feet have to fit our boots, not the boots our feet. A fashion in shapes is arbitrarily fixed, and the foot must conform to it, whether it be broad or narrow, long or short. Boots made by the careful man from one's own last have to be grown into, as it were. The laborious lacing of boots should not be necessary. We cannot go back to the unventilated sidesprings, and no buckle has yet proved satisfactory. There is abundant scope here for the inventive. Papier-maché proves impervious to the weather when employed as a material for houses; might not it make a good substitute for leather?

Better Shoes for Horses. Horses, too, might be better shod. A scandal of daily life is the strain to which these friends of man are submitted in their attempts to get a foothold upon the glassy asphalt over which they have to drag their loads. After all the ages during which horses have been shod, the farrier should be capable of something better than a crescent of smooth iron, which, while saving the hoof to a certain extent from the effects of the "hammer, hammer, hammer on the hard high road," causes the hoof to break away around the many nails which must be driven into it in the course of a horse's career, and, at the same time, does not enable the animal to get any real purchase upon a road which is at all smooth. Horse-masters should lend encouragement, too, to the man who will turn out a cart capable of being nicely adjusted when a heavy load is to be carried. The right position of a load for uphill is wrong for downhill, and *vice versâ*; but present-day carts admit of no alteration, and so our horses' withers are wrung. Years ago a man produced a mechanism which enabled the driver, by the turn of a lever, to bring forward or force back the body of the cart, so as to balance the load and ease the horse uphill and down. But the invention, simplicity itself, and perfectly efficacious, has never come upon the market. Perhaps it was too manifestly humane to succeed;—a more drastic form of bearing-rein might have been more acceptable.

A man with a bent in the right direction might do something to improve the umbrella, which is now as it has been through all its long history, nothing but a shelter for the hat. Tailors who give us "waterproofed" cloth for our coats might submit the cloth for our trousers to similar preparation. To keep the shoulders and knees immune from damp is very desirable, but chill seizes one just as readily from damp trouser-legs.

The Automaton. Upon every tram, 'bus, train, and other vehicle we ought to have a post-office; in every important thoroughfare there should be a public office in which one could see a directory upon payment of a penny. Telephone call offices ought to be multiplied in all streets and public places. Automatic buffets similar to that in the Thames Embankment Gardens should be in every public park and square lying upon the route of the poor. The automatic buffet is one of the institutions of the future.

Such are a few of the directions in which the inventive may turn their attention. There are many more, though not all appeal so directly to the individual. Every pillar-box should be a local guide, telling not only, as some now do, the time of next collection and address of post-office; but the address of police-station, fire-station, and so forth; and, further, should supply, on the automatic plan, all requisites for a letter. We may even hope some day to see pillar-boxes developed so as to automatically receive telegrams, to be dispatched by the sender by pneumatic tube to the nearest telegraph-office.

The Children. There is a fortune for the man who evolves an entertainment for children. Not all parents desire to take their children to pantomime or circus. The former is not invariably the most delicate form of entertainment extant; the comedian who can always keep humour and vulgarity apart is not found on every stage. The circus frequently becomes wearisome to the child. The children want their own Grossmith; the man who will sit down on the platform and tell them the prettiest stories in the world, sing them dainty little songs; and have upon his programme an item or two of the frankly "funny" character, but rigidly mindful of propriety. To such an entertainment one half of London would take its children, and country cousins would accord it as definite a place upon their programme as the Abbey and St. Paul's.

The child at home, too, is worth cultivating. We want more games—games with some purpose, which teach a little as well as amuse. There are millions of pounds in toys and games. Originality in Christmas crackers, a departure from caps and inane doggerel, is a feature which is developing, but there is still room for a tremendous advance.

Every trade and profession and vocation is overcrowded, we are told by those who are in them. As a fact, however, there is not a walk in life in which men and women of ideas may not launch out upon new lines, and gain wealth and reputation.

To be continued

BEGINNING AND CONTINUITY OF LIFE

How to Study Biology. Homology and Analogy in Structures. Classification. The Process of Reproduction and the Continuity of Life

By Dr. GERALD LEIGHTON

How to Study Biology. We now come to consider the question of the methods of study in biology. How are we to set about our inquiry into the various aspects of living creatures? What methods are we to employ? For our purpose those methods may be summed up in the statement that we shall endeavour to ascertain how living things resemble each other and differ from each other, and especially how these differences are brought about. Our study of life is mainly that of likenesses and unlikenesses, their origin, development, transmission, and evolution. It is a study, therefore, partly of structure, in so far as we compare the structures of animals; partly of function, in so far as we compare the various ways in which the structures perform the tasks of life. If the matter be probed to the bottom, it is seen that as a matter of fact an animal can only resemble another or differ from another in one or both of these ways. All other distinctions depend ultimately upon these.

The most casual observer cannot fail to notice that there are likenesses and unlikenesses in animals. Watch a cat at play, and we are immediately reminded of a tiger. Observe the flight of a bat in the evening, and that of a bird is at once suggested. The environment and motion of a whale seem to be those of a fish, and so on. These points of resemblance are quite obvious, but many resemblances are, on the other hand, only discovered after most careful comparison and study. Not only so, but there are different kinds of likenesses as well as different degrees. One part of one animal may be like that of another in its structure, but quite dissimilar in function; while, on the other hand, two widely differing structures may perform identical functions. For example, the wing of a bat and the wing of a bird are both used for purposes of flight; they perform similar functions. Moreover, they are structurally somewhat similar, differing in detail. But the wing of a bird and the wing of an insect, although both alike are for flight, have nothing in common as regards their structure. In other words, we find that likenesses are due either to parts exhibiting homology or analogy, the difference between these being very important.

Homology Defined. Homology is defined as "identity of structure in parts or organs, independently of function." Thus it makes no difference whether a structure is used for walking, climbing, swimming, or flying: if it be identically of the same structure it is an example of true homology. The part is a *homologue* of some other part with which it is compared. Thus the arm of a man, the wing of a bat or bird, the flipper of a whale, and the pectoral fin in some fish, all being built upon the same morphological type, are said to be homologous. The importance of noticing homology where it exists is this, that homology points to a common origin of the structures, and is therefore of great consequence in classification. It is of no significance from this standpoint that the arm of a man and the wing of a bird are used for different purposes; they are built upon the same fundamental plan, and are therefore homologues. It follows from this that structural likenesses are by far the most important guides to classification, the functions of similar parts being so very dissimilar as to put function out of court as a reliable guide to classification.

Analogy. On the other hand, we find *different* organs in different animals engaged in the performance of the *same* functions, and such organs or parts are said to be *analogous* with each other or *analogues*. Analogy in biology, therefore, means "identity of function quite independently of structure." Thus the wing of an insect and that of a bird are analogous organs, both being used for flight, but they have nothing in common in their structure. They have no common type of structure, but perform similar functions. But it must not be forgotten that in many cases analogous organs have more than this superficial resemblance of similar function: they are often constructed upon the same structural plan, in which case they are both analogous and homologous. Thus the leg of a man and the hind leg of a dog, being built upon the same type and used for the same purpose, are both homologous and analogous organs.

Classification of Living Creatures. The next point for consideration is that of classification of living creatures, which is a matter of convenience of description and reference. This, again, is founded upon morphological likenesses and differences, the result being the arrangement of a number of very diverse living objects into a number of smaller or larger groups, according to their greater or less structural resemblance to each other. A system of classification on these lines is good or bad according to the nature or number of the characters which are taken as determining the likenesses. There can be no hard and fast rules laid down. Classification is not a product of nature, but of the human mind; it is useful and convenient—indeed, a necessity, but purely artificial. The term "artificial" is, however, restricted to systems of classification which depend entirely or chiefly upon external and superficial resemblances. Thus, according to an artificial classification, a whale would be placed

upon the same footing and in the same group as a fish, in spite of the fact that it differs from a fish in every essential point of structure, simply because it so happens that it lives in the water.

Natural Classifications. So unsatisfactory are such "artificial" classifications that biologists have given them up altogether and adopted what they term natural classifications, which endeavour to group creatures into divisions depending upon a due consideration of all the essential points of structure presented by animals, apart altogether from the external shape of the animal or its habits and surroundings. When looked at in this way, a whale is found to be one of the mammalia and not a fish at all, in spite of its shape and aquatic habits. Such a natural or philosophical classification involves due consideration of true resemblances and differences which, as we have seen, depend upon similarity of structural type. The more perfect such a classification is, the more information it gives. Thus, if a whale were classified as a fish, all that would be expressed by that would be that its body was fish-like and its habits marine; whereas by placing the whale among the mammals, we are told at once that whales have their young born in a comparatively helpless state, that the mother has special mammary glands for the nourishment of offspring, and that hairs are found on some part of the body, characters which no fish presents. In a word, classification depends upon a careful discrimination between homologies and analogies, likenesses of analogy alone being entirely disregarded, likenesses of homology being relied upon as the only safe guide to affinities.

A Species. Having clearly grasped these essential principles of classification, all that is necessary here is to take an example and show how the principles are applied. Before doing so it may be well, however, to say a word about that much-discussed term a species. The animal *kingdom* is subdivided into *sub-kingdoms*, these into *classes*, these into *orders*, these into *families*, these into *genera*, and finally these into *species*. A species is the smallest *definite* division of animals that naturalists accept, each species or "kind" of animal resembling all its individual members in all essential characters of structure and being able to breed amongst themselves so as to produce similar individuals to themselves. If a number of such individuals have some peculiarities in common, they are termed a *variety*, and if these peculiarities are constantly present in their offspring, these are sometimes termed a *race*. Thus all dogs belong to one *species*, the species *Canis*, although there are many varieties of dogs. To distinguish a variety from a species is sometimes a matter of very great difficulty, simply because nature does not divide animals in this way at all, though man does so for convenience sake.

The classification now adopted by naturalists will perhaps be better understood if we take an actual example, and see how it is applied in practice. If we regard the domestic dog, with all its subordinate varieties, as a single *species*, we have to notice in the first place that it is technically known by a *double* name, and is called the *Canis familiaris*. All species are thus known by "binomial" designations, the *second* name being like a man's Christian name, and being distinctive of the *individual*, whilst the first name is like a man's surname, and indicates the group or, technically, the *genus* to which the individual belongs.

An Example of Classification. The dog, then, whilst individually recognised by the epithet *familiaris*, belongs to the genus *Canis*, in which are included other related species, such as the wolf (*Canis lupus*) and the jackal (*Canis aureus*). The genus *Canis*, again, belongs to the family *Canidæ*, including other genera, such as the foxes (*Vulpes*). The family *Canidæ*, again, is one of a number of families, such as the lions, tigers, and cats (*Felidæ*), the bears and racoons (*Ursidæ*), the hyænas (*Hyænidæ*), etc., which together constitute the order of the *Carnivora*, or beasts of prey. The *carnivora*, again, constitute one of many orders of quadrupeds which are distinguished by suckling their young and by other common characters, and which collectively constitute the class *Mammalia*. Finally, the class *Mammalia* is united with the classes of the birds, reptiles, amphibians, and fishes, to constitute the great primary division of *vertebrata* or vertebrate animals; since all these classes agree with one another in the fundamental character of possessing a backbone or vertebral column, or an equivalent structure. Condensing the above, the zoological position of the dog, expressed in full, would be as follows:

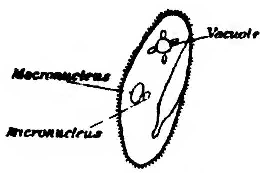
1. Sub-kingdom: *Vertebrata*.
2. Class: *Mammalia*.
3. Order: *Carnivora*.
4. Family: *Canidæ*.
5. Genus: *Canis*.
6. Species: *Canis familiaris*.

In an ordinary way it is quite unnecessary to employ in practice any of the above names except the last or *specific name*, since that implies all the others. (Nicholson.)

Likenesses and Differences. When we apply all these methods of study of living creatures to any one form, in order to complete its description and classify it correctly, we begin with the simplest possible structural tests, and proceed to more complicated likenesses and differences. Thus the very first point that would arise would be the number of cells in the creature, whether *one only*, or more than one; in other words, whether we were dealing with a unicellular protozoan or with a metazoan (as all many-celled animals are termed). If the former were the case, the next inquiry would be directed to ascertaining whether there were any indication of specialisation of function in this single cell or not.

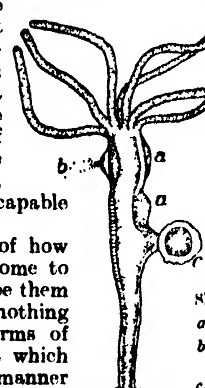
We have seen that most unicellular organisms exhibit no real specialisation of function, all parts of the protoplasm acting indifferently as organs of nutrition, reproduction, and relation. Directly we come to deal with multi-cellular or metazoan animals, however, we find certain cells being set aside for the performance of special functions, the first sign of the higher evolution of organised beings.

The Problem Re-stated. It is here that we come to the question of "How?" We have cleared the way to the study of this question in the preceding pages, and now approach the more interesting part of biology, which can only be understood, however, after a due appreciation of the methods of study already described. In order to be perfectly clear, let us re-state our problem. What can we learn from biological science which will enable us to realise in some degree how living creatures have been produced in the infinite variety in which we see them in the world? Various methods of investigation already enumerated are open to us. What do they teach us concerning the continuity of life, and the origin and transmission of new characters in living creatures? What do we mean by evolution, and how has it come about? What is the meaning and significance of heredity, and how does it tell in the world? Finally, how are all these all-powerful factors acting at the present time upon the highest product of evolution, Man himself? This is to be our study in the following pages. Without entering into technical detail, we may still hope to learn something of the infinite grandeur of the whole conception as it unfolds before us, and to rise from the study more capable of seeing life whole.



4. PARAMŒCIUM.

In approaching the question of how the manifestations of life have come to be so many and so varied as we see them to be in the world to-day, to say nothing of vast numbers of living forms of bygone ages, the very first point which demands our attention is the manner in which the life of one generation is continued into the next.



5. HYDRA.
Showing—
a. Sperm-sacs.
b. Discharge of Spermatozoa.
c. Ovum.

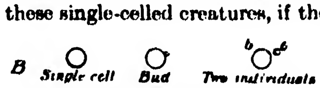
Continuity of Life. Everything depends ultimately upon this, and all the great biological problems of variation, natural selection and heredity centre round the great fact that there is a continuity of life from one generation to another by means of the protoplasm of the cell (in unicellular organisms), or of the germ cells (in higher animals). Curiously enough, this fact—which is obvious in those lowly organisms which reproduce by simply dividing into two—has been recognised in the higher animals only within recent years. In modern biological literature it is spoken of as the "continuity of the germ-plasm."

6. REPRODUCTION BY FISSION.

The various modes in which the continuity of life is made possible are, in other words, the methods of reproduction in living creatures. It has been already mentioned that the very simplest of these methods consists in the division of a single-celled organism into two separate individuals, by a simple process of *fission* or *budding* [6 and 7]. The former process, fission, is seen in bacilli, in which a constriction appears about the centre of the cell and ultimately divides the cell into two. In these simple examples it is quite obvious that all the characters of the single-celled organism *A* or *B* (both of them being undifferentiated masses of protoplasm with no specialisation of function) will be present in the next generation *a a* and *b b*, their offspring.

Except in their size at first, *a a* and *b b* are exactly like *A A* and *B B* as far as we can determine. They could hardly be otherwise, inasmuch as the latter produced the former by simply giving up part of themselves. In their turn, *a a* and *b b* having grown to maturity, will themselves divide and thereby produce the next generation with similar characters to *a a* and *b b*, as well as to *A A* and *B B*. So like produces like, and unless there were such a thing as variation in protoplasm, the offspring of *A* and *B* would never be anything different in any respect from *A* and *B*. But leaving the question of variation for later treatment, the immediate point is that the continuity of life depends upon the protoplasm of one generation being the basis of the appearance and growth of all succeeding generations, which therefore resemble *more or less* their ancestors.

A Race Dying Out. Such methods of production as fission and budding, the simplest of all reproductive processes, are, of course, non-sexual. The unicellular plant is not specialised in this way. But a very little higher in the animal world we find organisms departing from this extremely simple mode of reproduction and exhibiting processes which foreshadow the true sexual method. Some of these single-celled creatures, if they be separated and isolated and closely observed, are found to be limited in their powers of reproduction by simple division. The time comes when they will no longer continue thus dividing into two. This comes gradually, after the offspring have shown signs of deterioration in size and activity, in fact, all the symptoms of a race dying out.



7. REPRODUCTION BY BUDDING, OR GEMMATION
(as occurs in many globular single-celled organisms).

This foreshadowing of more complicated methods of reproduction is of much importance and significance. The process is admirably seen in the simple little creature found in an

infusion of hay water, known as *Paramœcium*, or the "slipper animalcule," the latter name being given on account of the shape of this organism. Paramœcium is just visible to the naked eye as a whitish speck. Under the microscope it is found to have a complicated structure for a single-celled organism [4].

The Maintenance of Vitality. This little creature reproduces itself in two ways, sexually and asexually. The asexual reproduction is a very quick process, and consists simply in a fission of the cell transversely into two parts, this being preceded by a division of the nuclei within the cell. The significant point is this: that the asexual method just mentioned cannot go on indefinitely. If a single paramœcium be isolated in a vessel by itself and allowed to reproduce in this way undisturbed, it is found that after a certain number of generations have been produced asexually, some of the resulting offspring show signs of deterioration. They are smaller than the first ones. If the process go on still further, this result becomes more and more pronounced, until ultimately the power of reproduction by this method disappears. In a word, it is necessary to introduce a new paramœcium in order that what we term the vitality of the protoplasm may be maintained at its proper standard of physiological activity.

Two Sexes in One. If this be done, a very remarkable series of changes follows. What appears to be a process of sexual reproduction takes place. At any rate, conjugation of two individual paramœcia occurs, by means of which an exchange of protoplasm is effected between the two cells. It is the simplest case of sexual reproduction we know, and yet in its detail is really somewhat complicated. The point to note is that two paramœcia come into contact by their ventral surfaces, and that this is followed by a series of changes in their respective nuclei during which each fuses to some extent with that of the other, after which the two organisms separate from each other. The nuclei which unite are called male and female. On the completion of the process each individual divides, so that from the original two parent organisms four individuals result.

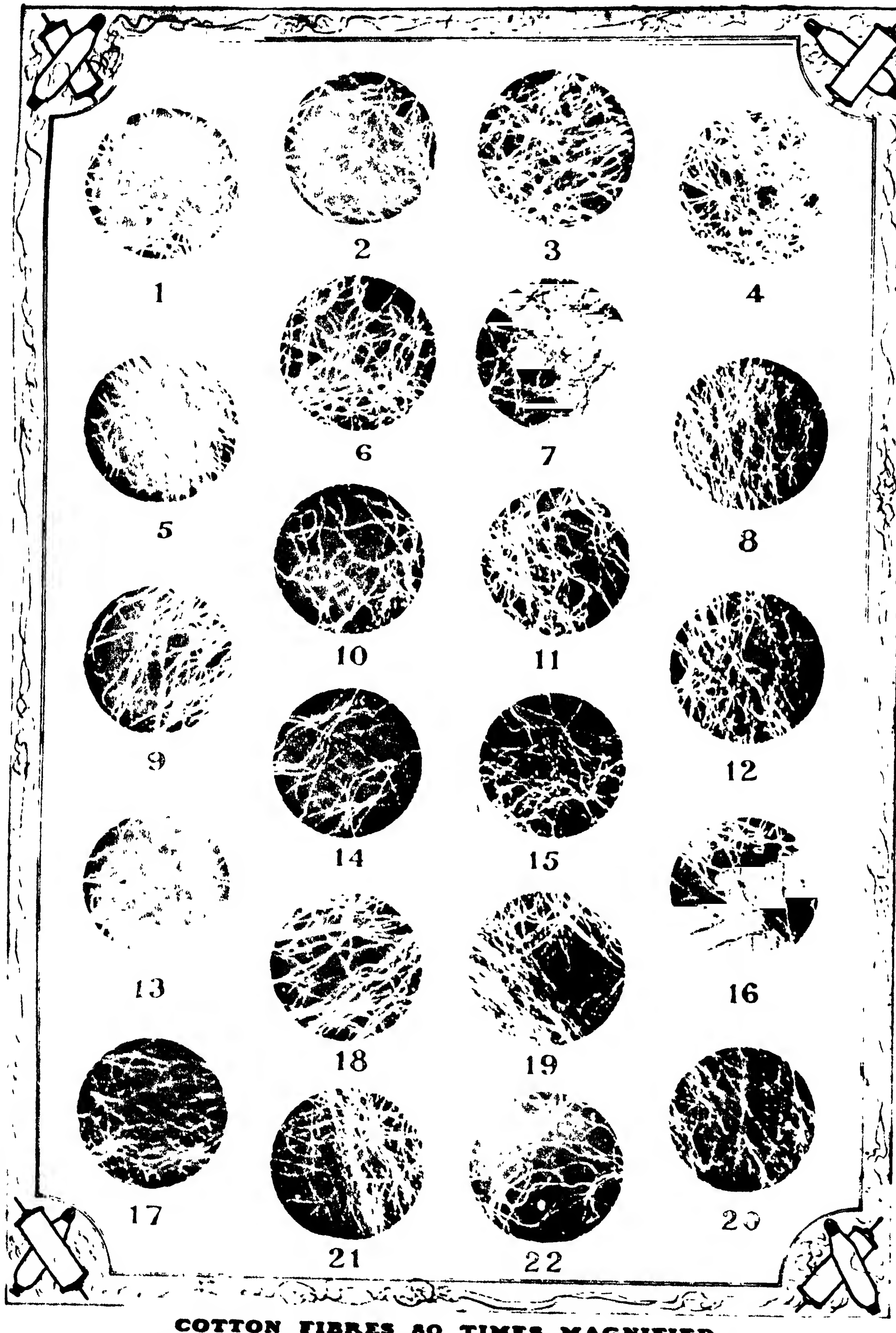
"The fundamental act in the whole series of these complex changes is the fusion of the male pronucleus of one individual with the female pronucleus of the other. But as far as it is possible to ascertain, the male and female pronuclei are identical, unless the fact that one migrates while the other remains stationary can be considered a difference of any importance. There is, therefore, apart from this act of migration, no differentiation into a male spermatozoon and a female ovum. And there are reasons for regarding this phenomenon of the fusion of identical masses, but derived from two individuals, as a rudimentary sexual act; that is to say, that in some such way as this sexual reproduction first arose. And we speak of this act as one of *Conjugation* in order to distinguish it from that definitely sexual one where the male element can be distinguished from the female in virtue of its size, form, and movements." (Mudge.) These half-way processes, if we may use the term, are of supreme interest to the student of biology. They bridge the gulfs between the simple and the specialised, and it is because of their existence that we are forced to believe in the gradual evolution of the complex from the simple, and in the oneness of the great plan which underlies the whole creation.

Steps in Evolution. We have now referred to reproduction in two of its modes of occurrence, by simple division of a one-celled organism into two as in an amœba or a bacillus, and secondly as a rudimentary sexual act in the conjugation of Paramœcium. Next we may turn our attention to another little creature termed *Hydra* [5], in which we shall find still further elaboration for the purposes of reproduction. Hydra is a fresh-water organism to be found in ponds and sluggish streams, frequently attaching itself to some of the water-plants or other floating objects. It can be observed quite easily by simply confining it in a transparent glass vessel in which is placed some water-weed. One end of this creature is seen to be attached to some object in the water, while the free end carries a number of minute tentacles just visible to the eye.

The reproduction of hydra is remarkable in that it takes place in two distinct ways. During the spring and summer hydra reproduces itself rapidly by an asexual process of budding, but later in the year, when the temperature falls and food is more difficult to obtain, a very extraordinary thing happens. A true sexual reproduction takes place. "At this period two little eminences appear upon the surface of the body, one being conical in form and situated in the upper part just behind the ring of tentacles, and the other lower down and somewhat rounded in form. The upper one is the *testis*, and the lower one the *ovary*. The ovum or egg becomes fertilised and undergoes an immediate preliminary development, by which the embryo becomes encased in a hard investment, and then it sinks to the bottom of the water, where it remains dormant until the early spring of the next year." (Mudge.)

Two Phases of a Life-history. We have, therefore, a life-history of two distinct phases, the one being that of a number of individuals which have been developed asexually, the other a number developed sexually. The asexual parent produces offspring asexually which develop sexual organs and reproduce the next generation sexually. These in their turn reproduce asexually again, and so on. This alternation of an asexual individual with a sexual one occurring in the life-history of a species is called an *Alternation of Generations*. It is not uncommon in the sub-class of animals to which hydra belongs. It carries us one step further in the methods of reproduction, a process which in all the higher animals is carried out only by the sexual method. In that method certain cells, the ovum and the sperm, are set aside for the special process of reproduction, and in their intimate structure is the mechanism by means of which the characters of the species are transmitted.

To be continued



COTTON FIBRES 80 TIMES MAGNIFIED

1 Western Madras. 2 Coconada. 3 Tinnivelly 4 China. 5 Broach [fine machine ginned]. 6 Machine Ginned China. 7 Bombay Waste 8 Tipperah. 9 Fine Comrawattee [fair staple]. 10 Comilla. 11 Dhollerah 12 Bengal. 13 Northern Madras. 14 Salem 15 Machine Ginned Bengal. 16 Scinde. 17 Egyptian. 18 West Indian. 19 Egyptian. 20 Sea Island. 21 Sea Island. 22 Haytian

Group 28
TEXTILES
3
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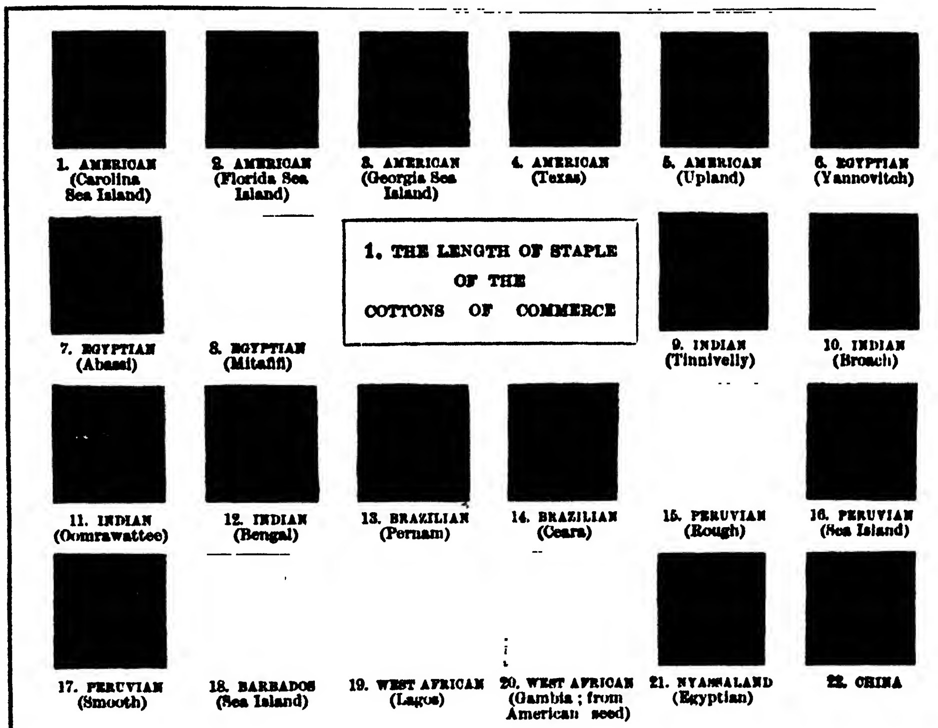
THE BEGINNINGS OF COTTON

The Development of the Cotton Industry—continued. The Cotton Field. Cultivation and Preparation of Cotton for Shipment

By W. S. MURPHY

South American Cotton. Resuming our study of the world's sources of cotton, we now turn to the product of South America. It is a curious fact that, while the natives of many tropical countries have produced cotton for centuries to supply their own needs, raw cotton has seldom been regarded by these populations as an export commodity. During long centuries the natives of India sold cotton cloths to foreigners without a thought of offering them raw fibre; the Chinese had spun and woven cotton for many centuries, and only awoke to the existence of a market for cotton fibre late in the nineteenth century; and many other nations and tribes, more or less barbaric, have bartered gold, pearls, shells, amber, gums, and fruits with the white stranger, while reserving the raw cottons of their fields for home use.

South America, soon after its discovery, became the prey of European adventurers there, and the Spaniards found a land better suited for colonisation than the northern half of the New World. In the Brazils, Bolivia, and Peru the invaders found soils suitable for cotton cultivation and a certain amount of production by the natives of those regions. By the year 1786 the South Americans had developed a large export trade, sending 5,000,000 lbs. of cotton to England alone. Six yea s later, however, the fibres of Peru and Brazil encountered the serious competition of the produce of Florida and the Mississippi valley. During the British-American War of 1812 the South Americans had an opportunity of re-capturing the English market, and again in 1861, during the American Civil War. But the South American lacks the business energy of his northern rival, and though the cotton supply of Peru and Brazil is always worth considering by cotton buyers, it is small compared with that of the United States.



1. THE LENGTH OF STAPLE OF THE COTTONS OF COMMERCE

Egyptian Cotton. Egypt was for some time regarded as the original home of the cotton industry, and very probably Egypt was

the seat of cotton manufacture in times long forgotten; but the definite assertions of Egyptian priority in cotton manufacture were founded on an error. Investigators wrongly supposed that the linen wrappings of Egyptian mummies were cotton. Such revelations of error ought to make historians of industry cautious and tentative in their conclusions. It is certain, however, that cotton was grown and *spun in Egypt long* before even the era we name *ancient was begun. Here the stay-at-home character of cotton strongly* shows itself. Not till 1821, under the strong rule of Mehemet Ali, did Egypt begin to export cotton. That year

us from disaster should the supply from the United States for any cause fail us. In the table given below the position of the cotton market at the beginning of the twentieth century may be seen at a glance.

Cotton Growing in the Empire. About the middle of the nineteenth century, when the cotton trade was extending so swiftly that it threatened to dwarf every other branch of the textile industry, a great doubt arose in the minds of the far-seeing members of the trade. Without the stern lesson of the "Cotton Famine," as the dearth caused by the American Civil War was called, these men perceived the unstable

TABLE OF COTTON FIBRES AT PRESENT IN USE

Country of Growth.	Variety.	Length of Staple. See Fig. 1.		Diameter of Fibre.	Average Counts of Yarn.	Description.
		Min. Inch.	Max. Inch.	Inch.		
AMERICA— Area of crop, 27,000,000 acres; Product (1903), 2,400,000 tons; Export to U.K., 607,650 tons	Sea Island	1⅝	2	1/[illegible]	130 upwards	Long, fine, silky, easily bleached; the best cotton.
	New Orleans	1	1¼	1/[illegible]	40–60	Most reliable of American cottons, some varieties white, others creamy.
	Upland	⅞	1	1/[illegible]	30–40	Soft, and adapted for weft.
	Texas	⅞	1	1/[illegible]	40–50	Fine, but rather dirty and dull.
EGYPT— Area of crop, 1,375,000 acres; Product (1903), 5,000,000 cwt.; Export to U.K., 2,780,000 cwt.	Mitafifi	1·3	1·6	Average 1/[illegible]	80–180	Brown, varies in quality.
	Abassi	1·4	1·8		60–80	White, mixes well with Sea Island, though a trifle harsh.
	Ashmouni	1	1·4		—	
	Yannovitch	1·3	1·6		80–120	Soft and fine, but brown in colour.
BRAZIL— Total Export (1903), 28,000 tons; Export to U.K. 18,000 tons	Pernam	1·4	1·50	1/[illegible]	40–60	All Brazil cottons are white and hard, giving yarn a wiry feel.
	Ceara	1	1·2		26–36	
	Maranham	1	—		40–50	
PERU— Total Export (1903), 7,530 tons; Export to U.K., 3,230 tons	Sea Island Peruvian	1	1·7	1/[illegible]	40–50	
	Rough Peruvian	1·2	1·5	—	30–40	Harsh, mixes with wool.
	Smooth Peruvian	1	1·1	—	30–40	Soft, silky and clean.
SMYRNA— Total Export (1902), 4,462 tons; Export to U.K., 254 tons	Yerli	⅞	1⅛	1/[illegible]	20–36	Strong, harsh, fibres irregularly twisted.
INDIA— Area of crop, 15,000,000 acres; Annual crop, 400,000 tons; Export to U.K., small amount	Surat	·80	1·20	1/[illegible]	16–26	Good working cotton.
	Bengal	—	·80	1/[illegible]	Low counts	Except when grown from Sea Island seed, Indian cottons are poor in quality and short in staple.
	Broach	·6	1	—	"	
	Rangoon	·8	1	1/[illegible]	"	
CHINA— Annual crop, 300,000 tons; Export to U.K., 662 tons	Common	⅞	1	—	20	White, rough, short in staple.
WEST INDIES— Area of crop (1904), 14,000 acres; Product (estimated), 5,000 bales	Sea Island	1¼	2	1/[illegible]	80–120	Fair, but irregular in quality.
	Native	1	1·4	1/[illegible]	—	Lacking uniformity in colour.

944 bales were sent out, chiefly to England, and in the years following the amount rapidly increased, the average annual production being about five million hundredweights.

In sketching the history of the cotton sources we have detailed only those which are of prime importance in the cotton market. Other and smaller contributors there are. China, according to expert estimate, grows over 300,000 tons of cotton annually, but of this enormous total only about 45,000 tons are exported, the greater part being consumed in the country. Asia Minor, Cyprus, Java, and West Africa send small contributions; but these would not save

basis of the cotton supply of the world. The preponderance of the United States in the raw cotton market constituted a grave danger; that the main supply of so vast an industry should be liable to disturbance by purely local causes was rightly considered to be a serious risk. How true were the prognostications of those cotton manufacturers the Civil War proved in a fashion more emphatic than pleasant. In later years, the vast additions to the productive capacity of the United States notwithstanding, the menace has become even more threatening, and all those whose interests are connected with cotton, all who are in any way dependent on

the prosperity of the cotton trade, ought earnestly to seek to broaden the basis of the supply of raw material.

West Africa. While, in 1850, many manufacturers expressed alarm, and exclaimed, in the usual manner of alarmists, that something must be done, but did nothing, one man, Thomas Clegg by name, a citizen of Manchester, took wise action. We have called special attention to the stay-at-home disposition of cotton out of no idle motive. If there are tribes producing cotton for their own consumption, they are likely, if inducements are offered, to produce for the outside world. These cotton-growing, non-exporting peoples are like subterranean waters, which, in dearth of rains, can be tapped for supply. At the very least, wherever you find a tribe producing cotton for home consumption, you have a cotton field which may be made indefinitely more productive by the application of scientific methods of culture. These truths were perceived by Thomas Clegg. Knowing that the natives of West Africa produced cotton for themselves, Mr. Clegg established a native agency on the coast, buying cotton from the natives, and encouraging them to further production. His efforts met with considerable success. In 1852 he gathered 1,810 lbs.; in the year following, 4,617 lbs.; in 1859 the amount gathered by Clegg's agency was over 70,000 lbs. Though we have no further record of this man, his work has lived on, and from West Africa there has always been a continuous, though small, supply of cotton.

Organising the Cotton Supply. Lancashire cotton spinners as a body took some time to act, but in 1857 they formed the Cotton Supply Association, the constitution and methods of which exhibited the enterprise of its founders. This organisation of business men aimed at no direct profit, its objects being: (1) To supply seeds, machines, and practical instruction to those willing to engage in cotton cultivation; (2) To ascertain the capabilities and peculiarities of the various districts of the world where the plant may be, but is not at present, produced for export. For some time it seemed that this association had the power to solve the problem, and during the first years of its activity the outlook was hopeful. Cotton-growing was begun in Greece, Turkey in Europe, Tunis, Liberia, Gold Coast, Benin, Old Calabar, Australia, Cape Colony, and Natal. The association helped to renew the vigour of production in Cyprus, Asia Minor, Cuba, Peru, Barbadoes, Batavia, Java, Ceylon, and all parts of India. The calamity the Cotton Supply Association was born to avert came too soon, and almost destroyed it. We do not say that the Cotton Supply Association has failed; a larger, more comprehensive scheme of action was needed, that is all.

2. THE COTTON PICKERS

British Cotton. For forty years manufacturers as a body allowed the question of the cotton supply to sleep, practically starving the Cotton Supply Association, and trusting to the power of the market to call in supplies according to need. Near the close of the nineteenth century, however, the power of the speculator in the cotton market and the increasing demand for cotton both in the United States and Europe gave rise to acute uneasiness. At the beginning of 1902 the fears of the most pessimistic were more

than justified; during that year and the two succeeding years there was a shortage in the cotton supply, with the result that many mills in Lancashire and on the continent were run on short time or entirely closed, inflicting loss on both operatives and employers, and damaging the trade generally. Instant action was demanded, and the British Cotton Growing Association was formed in 1902, with a guarantee fund of £50,000 and with the avowed object of extending the cultivation and growth of cotton throughout those parts of the British Empire where the conditions might be suitable.

Cottons of the British Empire. A council composed of representatives of every important cotton interest was formed, and the capital raised. Effort was first directed to re-establishing the cotton-planting industry in the West Indies and improving the culture of cotton in India. British Central Africa and West Africa also claimed the attention of the association. By October, 1903, it was seen that the field of operations required a larger capital, and the guarantee fund was raised to £100,000; this sum was got without much difficulty. Next, in 1904, it was decided to incorporate the association by Royal Charter, with a capital of £500,000, and on August 27th the charter was granted. On this new basis the work was vastly extended, and the active co-operation of the Colonial Governments everywhere secured. The British Cotton Growing Association now has stations in British East Africa, Uganda, Rhodesia, South Africa, the Soudan, and other places already mentioned.

In 1905 an Exhibition was held at the Imperial Institute, London, showing cottons from many parts of the Empire not then recognised as sources of supply. From the information then given the table in this section was compiled. By combining the table of cotton fibres with this, we obtain a clear view of the raw cotton production of the world.

The Processes of Cotton. A man likes to know the more important incidents in the history of his trade; but the practical processes have for him a deeper interest. The trade begun in primitive simplicity under the trees of tropical Africa, Asia, and America has woven itself into the complexities of civilisation, and, taking on the colour and character of its environment, has become complex in process and diverse in product. Cotton manufacture includes many trades and a great variety of commodities. We intend to take the student through every department, giving to each the proportion of attention which we think it merits, and this is our itinerary.

First: We shall view the cotton field, the cotton plant, the methods of culture, the varieties of cotton, the sources of supply, and the plans adopted for the development of British cotton resources; gathering on the cotton field; ginning; baling.

Second: The cotton is next seen in the stores of the factory, where selection is made for the production of any particular yarn required; we follow the mixture thus selected to the opener that breaks the lumps of cotton into fleecy masses; to the scutcher, in which the fleece is further opened out and formed into a flat sheet; to the carding machines, whose teeth unravel and pull asunder knots and snarls, blending and smoothing the fibre so as to make it lie close together in the form of a light, soft, thick rope called a sliver.

Third: We follow the preparing process further, and see the slivers combined and drawn on the drawing frames, slubbers, intermediate, and roving frames, successively; finally entering the spinning room, where the roves are put on to the mule spinners to be fine-spun and drawn; and then, emerging from thence, we see the stream of yarns part, one going up to the reelers to be hanked for the dyer and bleacher, another to the twisters, another to the lace factory, and yet another to the warping-room.

Fourth: The reeling and twisting machines

COTTONS OF THE BRITISH EMPIRE

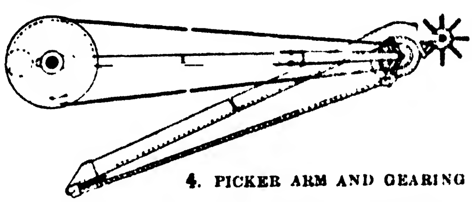
Source.	Description.	Length of Staple.
		Inches.
Africa, British Central	Egyptian	1·1 to 1·5
	Unknown variety	1·0 „ 1·3
	„	1·4 „ 1·5
Africa, British East	Kidney	0·9 „ 1·2
	Egyptian	1·0 „ 1·3
	Native	0·6 „ 0·9
Anguilla	Sea Island	1·5 „ 2·0
Antigua	Sea Island	1·6 „ 1·8
Barbadoes	Sea Island	1·7 „ 2·1
Borneo, North	Indigenous	1·2 „ 1·4
Burmah	Egyptian	0·8 „ 1·6
Cyprus	Grown on irrigated land	0·6 „ 1·0
	„ „ non-irrigated land	0·8 „ 1·2
	Native (2nd year)	1·0 „ 1·3
Fiji	Kidney	1·2 „ 1·6
Gambia	Native	0·6 „ 1·0
	American	0·8 „ 1·3
Gold Coast	Cotton from imported seed	1·0 „ 1·5
Honduras, British	Egyptian	0·9 „ 1·4
	"King" Upland	0·9 „ 1·3
Lagos	Native	1·0 „ 1·4
Malay States	Egyptian	1·2 „ 1·5
Natal	Kidney	1·0 „ 1·4
	Sea Island	1·7 „ 2·0
New Guinea	Native Gota	1·2 „ 1·4
Nevis	Sea Island	1·6 „ 2·0
Nigeria, Northern	Bassa Province	1·0 „ 1·2
	Kano „	0·7 „ 1·2
	Kontagora „	1·2 „ 1·4
	Nassawara „	1·2 „ 1·6
Nigeria, Southern	Native	1·0 „ 1·2
	American	1·2 „ 1·4
Queensland	American seed	1·5 „ 1·8
Rhodesia	Indigenous variety	1·2 „ 1·4
	Egyptian	1·4 „ 1·6
	Wild	1·1 „ 1·4
St. Kitts	Sea Island	1·6 „ 2·0
St. Lucia	Sea Island	1·3 „ 2·2
	Native Upland	1·2 „ 1·7
	„ Kidney	0·7 „ 1·1
St. Vincent	Sea Island	1·6 „ 2·0
	Mitafifi	1·3 „ 1·5
	Ashmouni	1·1 „ 1·3
Seychelles	*Gossypium Barbadense*, grown on Astove Islands	0·9 „ 1·3
	Unknown variety	1·0 „ 1·3
South Australia	Indigenous	Not stated
	American Upland	1·0
	Sea Island	1·2 to 1·5
Sudan	Native	0·8 „ 1·2
	Abassi, grown at Kamlin	1·3 „ 1·6
	Yannovitch „ „	1·3 „ 1·7
	Mitafifi	1·1 „ 1·6
Tortola	Sea Island	1·6 „ 1·9
Transvaal	Grown in the Zoutpansberg district	1·0 „ 1·2
	Indigenous	0·6 „ 1·0
	Native	0·9 „ 1·4
Trinidad	Upland	1·2 „ 1·4

3. AUTO-COTTON-PICKER

and material, promoting by co-operation the welfare of each and all.

The Cotton Field. The cotton plant (*gossypium*—p. 222) will grow on almost any soil, though the best results are obtained from a deep loam, with good drainage. Sandy soils usually produce plants of small growth, because the moisture rapidly oozes away from the roots in light soils. No cotton planter need place too much stress on a particular kind of soil so long as he gets depth for the tap-root, because it is not difficult to remedy any slight deficiency in the quality of the soil. Climate is the main factor in cotton growing. The plant takes seven months to mature, and during that time the climatic conditions must be favourable. Frosts, quick alternations of heat and cold, torrential rains after sun, and other violent variations, are inimical to cotton culture. The ideal climate is a warm, wet spring, early summer of uniform temperature, and dry, cool autumn. The ideal is the un-

must now be utilised to produce warp and weft, the latter being wound on to small cops, while the former goes on to large bobbins.



4. PICKER ARM AND GEARING

Fifth: We are now at the beginning of the weaving process. The warp is formed, wound on the beam, heddled and drawn. Then we mount and dress the loom, it may be with jacquard or dobbie, or some fancy mountings.

Sixth: We have to learn the meaning of all the loom gearings, and acquire an insight into the secrets of weaving design.

Seventh: The part of the yarn set apart for the making of sewing-thread has to be taken in hand and put on the twisting frames, then bleached, dressed, gassed, polished, and spooled.

Eighth: Our pursuit of the fine yarns for lace-making must be resumed, and we see the warpers forming great warps on the heavy beams, while on the spooling machines the weft fills up the narrow spools between the plates of the slender shuttles; and then we lay the warp in place, set the shuttles on the comb-bar, adjust the jacquard apparatus, linking every wire to its thread of warp, and begin weaving.

These are the outlines of our study. Not infrequently we join with other textile students, and in company learn the relation of one branch of the textile industry to another, often using the same machines, imparting and receiving, exchanging methods

5. INDIAN CHURKA

attainable, and climatic conditions remotely approximate have spontaneously produced good cotton.

The cotton planters of the United States have brought cotton cultivation to a high pitch of excellence, and a survey of their methods will help us to form an idea of the work entailed.

Growing the Cotton. During the winter the old plants are grubbed up, and the land is turned over with the plough. As soon as the frosts have gone the soil is thrown up into ridges. If the soil be strong and able to bear a heavy crop, the ridges are only about two feet apart; but in poor soils as much as six feet is allowed. In a good spring, when the weather has settled early, sowing begins about the middle of March; but in some seasons it is advisable to defer sowing till well on in April, especially on the northern edge of the cotton belt. The seed is sown in the ridges in holes about a foot apart, and covered over. Within ten days the green shoots begin to appear above the soil accompanied by weeds. Work now begins in serious earnest for the cotton planter and his hands. The first thing to be done is to thin out the plants, so that only one plant remains in every space of one foot in each row. When this is done, the weeds claim attention, and during the next month require assiduous hoeing or ploughing between the ridges to keep them down. If the weeding has been done systematically and thoroughly, the land may be rested at the beginning of the fourth month after sowing, and on to the time of ripening. This is to allow the soil to settle firmly round the roots and nourish the plants. Plants that show a tendency to grow much wood should be rigorously topped, to spare as much sap as possible for the fruit. In the fourth month the flowers begin to appear, and cover the fields with a sheen of gold and green. As the blossoms fade the bolls or pods begin to grow, and gradually swell. When the pods are ripe they burst, and from the capsules spring the white tresses of the cotton fibre.

Few sights are more wonderful than a cotton field when the fibre shows. The land wears a fleece of dappled white, the stems and foliage intensifying by contrast the dazzling purity of the wool, like the crowded mass of a million sheep miraculously washed. But the picture quickly dissolves, for the autumn winds are sharpening, and the pickers must work swiftly to harvest the crop.

Picking. Much ingenuity has been expended in devising mechanical cotton-pickers; but the difficulties to be overcome are subtle and baffling. The bolls grow at all angles on the plants, and the fibres stick firmly in the bolls. For a long time to come, we fear, the application of machinery to gathering cotton will be limited. A new cotton-picking machine [3-4], invented by Mr. George A. Lowry, a native of Ireland, resident in Boston, U.S.A., was tried in America during November, 1904, and pronounced a success. This invention does not supersede the cotton-picker, but facilitates his work, by an ingenious combination of power-driven hooks. The body of the machine is a gasoline engine with driving gear. At the four corners seats are placed for the pickers, and on both sides of the seats hang the picking-arms. These are ingenious contrivances, rods set in universal joints, along which run endless bands studded with hooks that, flying at the rate of 360 ft. per second, catch the lightest fibre.

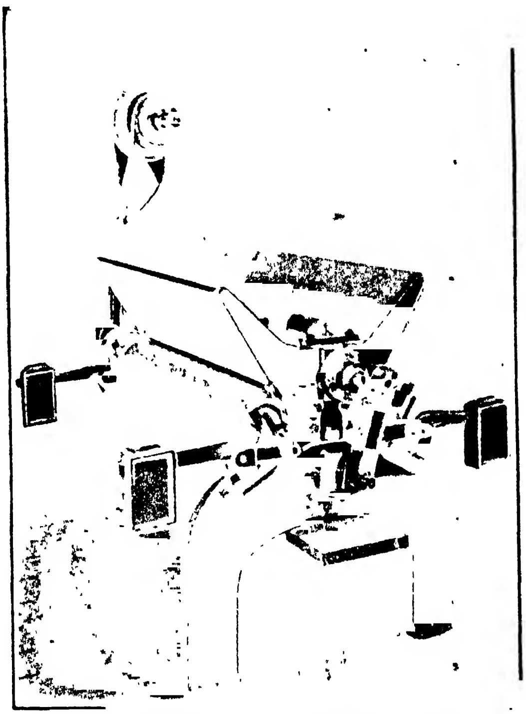
When the machine has arrived at the cotton row, the four pickers take their places, each having picking-arms on both sides of him. He directs the flying hooks on to the cotton bushes, and each little hook carries off a quantity of the fibre, being in turn deprived by a set of brushes, that sweep the cotton into suction tubes leading to the bags suspended from the overhead frame of the cotton-picker. The machine is worth the attention of men who are contemplating starting cotton-growing in those parts of the Empire where labour is difficult to procure. For the present, however, we must confine ourselves to describing methods actually in practice. Various districts have different methods of gathering. The old-fashioned way was for each picker to carry a basket slung on his or her neck, fill it and carry the cotton to the weighing-house near at hand. Others had large two-handled wicker baskets placed along the rows, a basket to each pair of pickers. The particular method adopted depends on purely local conditions, one of the most important of which is the custom of the natives who work.

The Planter's Problem. Here we meet with one of the most serious problems the cotton planter has to face—the labour problem. When a new industry is started anywhere, the difficulty of procuring labour is always considerable. Even in this crowded country, where nature yields nothing save to arduous labour, the early cotton manufacturers could not procure labour for the factories, and were compelled to resort to pauper children and train them up to the work. In the tropics food is easily procured, and the natives have few wants they cannot supply by very little exertion. To employ white labour is simply impossible. In one way and another the difficulty is, and shall be, got over. Contact with a higher civilisation creates in the native mind a desire for the things which can only be procured at the cost of labour. Long patience, tact, and perseverance, coupled with fair dealing, gather, in time, an ample supply of native workers round the British planter. The peace and security afforded by British rule have already encouraged the natives of tropical states to adopt a settled and industrial mode of life.

Ginning and Baling. Some large plantations have a central ginning house, situated at a point most convenient for all the fields, and employing steam-power. More common is the arrangement which attaches to every large field a gin-house. For a long time the planters of the United States cleaned cotton by hand, a process both tedious and costly. Wideawake as they were, it is wonderful that the planters of the west remained in ignorance of the *roller gin*,

or *churka*, used by the cotton planters of the East Indies from time out of mind. Simple as it is, the churka [5] is a most ingenious contrivance. The rollers thin to opposite ends, thus giving a transverse dragging motion. Each tuft of cotton contains within it a mass of seeds. To separate the seeds from the cotton is the work of the gin. Holding the cotton in one hand and feeding it to the rollers of the churka, the Indian turns the handle with his other hand. The rollers drag in the cotton and squeeze back the seeds, which drop on the inside while the freed cotton falls on the other side.

Left to their own devices, the Americans did not take long to invent a ginning apparatus. In 1793 Eli Whitney invented the saw gin. Though a rough and simple contrivance, the saw gin contained the idea which has since been developed into modern machines of high efficiency. The machine consisted of two parts, a wire hopper and a roller. On the hopper the wires were set close together, so that the cotton seeds could not pass through; on the roller were wound a series of saw blades; the teeth of the saws, slightly hooked, were set between the bars of the hopper. When the cotton was fed in and the roller set going, it dragged the cotton through, leaving the seeds to fall to the bottom of the hopper.



6. THE DOUBLE-ROLLER OR MACARTHY GIN

Improving the Gin. For short-stapled cottons, the saw gin was an efficient seed-separator, but long-stapled cottons of fine quality, such as Sea-island, were torn and greatly reduced in value by the machine; but the planters saw the advantage of using machinery, and went in search of an appliance that would suit. The Indian churka might have answered the purpose admirably. The working of the roller-gin, however, though suitable to a land where time is cheap and wages low, was too slow for the planters of America. The saw gin, it seemed, must be improved, and it was—with results we have now to review.

Whitney's saw gin had several serious faults, the chief of which were the tendency of the saws to clog and the injury done to the fibre by the sharp drag of the saws. The first was

7. GINNED COTTON

partially remedied by a brush arrangement at the side of the roller, and the second was also modified by an adjustment of double cylinders. Another improvement of the saw gin was the attachment of a fan which helped to clear the cotton of dust while it passed through the gin.

Other inventors were quickly in the field, and a host of cotton gins, each advertised as better than every other, have been put at the disposal of the planter. We will look at a few of them and try to appreciate the merits of each, without making too much of any. The *Double-roller Gin* [6], sometimes called the *Macarthy*, was one of the earliest independent inventions designed to combine the merits of the saw-gin and the churka. On the top is a hopper beneath which run a pair of rollers, spirally grooved. Within the hopper knives are fixed, geared so as to press against the rollers, their pressure being regulated by a set of weights hanging outside the hopper. When the cotton is laid in the hopper and the gin is started, the rollers drag the cotton down, the knives press the fibres against the grooves of the rollers, the sharp edges effectually hindering the seeds from passing through and freeing the cotton from them. The seeds fall into the box below, and the cotton gathers in a heap under the end of the machine.

Other Varieties of Gin. The *Knife Roller Gin* is very similar in principle to the Macarthy Gin, with additions of some ingenuity. Leather-covered rollers revolve under the hopper against fixed knives named *doctors*. The characteristic feature of this gin is the cylinder fitted with spiral knives that run on the fibres as they are drawn down by the rollers and fixed knives, carrying off the seeds, and clearing them of fibre. The spiral movement is here transferred from the rollers to the cylindrical knives, and it is claimed that a higher rate of speed is promoted thereby; but upon that we pronounce no opinion.

Different from the two already described is the *Lock-jaw Gin*. Above the roller is a movable blade, and in front are beaters. As the cotton is drawn forward by the roller, the beaters strike upon it, and the knife moves down on the roller, forcing the beaters to denude the fibre of seeds completely. We have been much struck by this gin, because it removes a large amount of dust and adhering vegetable matter as well as the seeds. On the other hand, rival models are equally admired by many practical men.

These three machines are typical representatives of the many models of roller gins at present on the market. Whatever may be the model chosen, it ought to possess three special qualities. First, it must thoroughly search the fibre and remove the seeds; second, swiftness of action is most desirable; third, the gin must not injure the fibre. If, in addition to these indispensable qualifications, the gin has the power to clean the cotton or improve the fibres, so much the better.

Baling. When the cotton issues from the gin, it is opened out [7], a pound occupying a considerable space. This openness would be a desirable quality if the cotton mills were only a few yards from the cotton fields. At present, however, the planter grows cotton for a distant market, the great bulk of it requiring to be shipped. Loose fibre cannot be shipped. The pressed bale is the only alternative, and it has been adopted. When machinery was not so readily available as now the feet of the field hands were employed; but that method of pressing has long been discarded in favour of the hydraulic press. Another point to be noted is that the cotton manufacturer has always liked his bales to be of uniform weight. Weight has to be considered in calculations of cotton manufacture, and it is well to begin at the beginning. Accordingly, the presses now used by the leading planters in pressing cotton are also weighing machines. Under the ram of the press is a box, and into this the elevators pour the cotton, which is pressed down as it comes in. When the proper weight has passed into the box, a lever is freed, and down comes the whole pressure of the ram, squeezing the mass into a solid lump, oblong in shape, with square sides. In such shape cotton can be packed into small space in the hold of a ship or on railway trucks.

The hydraulic press with which we are most familiar is one of many; but the principle and object of all baling presses are the same. The bales are covered with coarse canvas, sewn up and hooped. In this condition the cotton is ready for shipment.

To be continued

THE SPIRIT OF THE WORLD

Economising Time and Money. The Atmosphere of a Foreign Land. Attractions and Advantages of many Countries. Guides

By J. A. HAMMERTON and WM. DURBAN, B.A.

HUMAN nature is proverbially gifted with the capacity of adaptation to almost any set of circumstances and conditions which may be encountered in life. But for this natural faculty very much of life would be almost unendurable. Those who possess it in the highest measure make the happiest travellers.. For it is impossible to gain either enjoyment or benefit from travel without some degree of assimilation. We must, in order to appreciate the peculiar features of a country, or the special characteristics of a strange people, place ourselves in the mental attitude of appreciation. Psychology is national as well as individual, and there is in any community a collective soul that invites our study. The "spirit" of a country is determined by multitudinous complex factors, such as climate, racial affinity, history, heredity, struggles in the past (whether for independence or for subsistence, or in industrial and commercial competition), intellectual proclivities, geographical position and religious customs.

"Getting into the Atmosphere." The sympathetic traveller unconsciously absorbs much of the spirit of the new country that he enters, and hence the delight of travel. The sense of novelty is constantly renewed as the wanderer moves along the pathway of an extended journey. He marks the alertness of the Americans, the acumen of the Germans, the vivacity of the French, the serenity of the Swiss, the dignity of the Spaniards, the elasticity of the Italians, the animation of the Austrians, the courtesy of the Danes, the simplicity of the Scandinavians, the sturdiness of the Finns, the geniality of the Russians, the manliness of the Turks, the acuteness of the Greeks, the light-heartedness of the Roumanians, the reserve of the Arabs, etc. And he finds, on studying the causes which produce the demeanour of any particular people, that these causes are as interesting as the resultant effect which is attracting his interested attention. It is thus that travel contributes to our education.

The Uses of the Guide. If the traveller is willing to make the most of the things which range themselves under his observation, he can go nowhere without great gain. The true traveller does not practise the flippant "touch and go" system which implies the vulgar "doing" of districts for the sake of vaunting that they have been "done." This wretched fashion makes the very least of everything, and is a profane waste of time, money, and opportunity. One of the main recommendations of a foreign tour is that it develops the finest perceptive faculties, cultivates a variety of tastes, and impresses knowledge indelibly on the mind, by presenting to us countless concrete facts, and bringing us into actual contact with the world's realities.

As little time as possible should be spent in mere lounging in hotels and in pensions, in concert-halls and theatres, for when the tourist is on the wing there are usually endless peculiar local objects claiming his interest, and mere amusement may almost always just as easily be found in resorts in our own country. For any who are physically weak, and are seeking to recuperate, the most expedient method is to select some one of the many lovely spots on the Continent as a centre, and to indulge in easy little excursions round about it. Intimate acquaintance is thus cultivated with charming native village life and its novel conditions.

How Time and Money are Saved. Those who for the first time visit a city of any magnitude beyond the familiar range of Continental travel, more especially if they have but a short time to spend in viewing its sights, should make a point of sacrificing their independence and engaging a skilled guide. Especially should they do this if they have no knowledge whatever of the language. A guide-book is of course indispensable, but it is not always adequate for the purpose of the visitor who is an entire stranger in a great foreign city. An English-speaking "cicerone" is usually to be found hanging about any first-rate hotel in any one of the most populous cities. In Athens are several most intelligent men who will undertake for a remarkably reasonable charge, as we ourselves have tested, to pilot the traveller through any part of Greece, and will so manage the tour as to save the funds of those employing them to an extraordinary extent, simply because they perfectly "know the ropes." The visitor who attempts to find his own way about such places as Constantinople, Smyrna, Ephesus, Nijni Novgorod, Moscow, Warsaw, Kieff, Syracuse, on his initial visit, will either lose himself or else lose the chance of seeing many of the very objects most worthy of his inspection. A competent guide magnifies and multiplies the interest in many directions. He saves time and he has a thousand things to tell that are worth hearing.

The Needless Risk of Life. Perhaps the acme of folly is that of which inexperienced tourists are guilty if they venture to explore dangerous mountain districts alone. Life should surely be counted too precious to be thus recklessly risked. Glaciers, with their beautifully terrible crevasses, avalanches, snowfields, chasms, precipices, mists, and falling stones, are not to be trifled with. Even the

most adventurous spirits should take every reasonable precaution.

Arranging for Guides. In traversing certain of the districts in Calabria, and in Sicily, and in Greece, which were not many years since the favourite haunts of brigands, we have been repeatedly told how men employed by unwary foreigners would lead them actually into the traps laid for them. Even now there are attractive regions where it would be folly to make use of the proffered services of any but a registered guide. Apart altogether from the question of danger, the tourist may be subjected to a variety of tricks. He may find the men leading him ignorant of the way. We have known persistent attempts made in the middle of a mountain pass to extort from the traveller double the amount of the fee agreed on, under the pretext that the weather was not agreeable, or that the baggage being carried on the shoulders of the guide was extra heavy. Above all, it is vitally necessary beforehand to have a definite agreement, in presence of the hotel landlord or the Mayor of the Commune, as to terms. This is easy enough, because almost universally in places of familiar resort there is a printed Government tariff regulating every particular. Nothing is more useful and nothing is more essential. Never employ any guide who is not authorised or recommended. Many an unfortunate and unsuspecting tourist has been victimised by engaging the services of some volunteer in the Swiss or Italian Alps not on the list of the "authorised guides." The Italian Government is specially solicitous concerning the dealings of native conductors and "ciceroni." In every little town may be found young men and lads wearing on their caps the magic words which are the envy of other youngsters, "Guida Autorizzàta."

Without Guides. Nearly all experienced travellers can recall sad illustrations of the principle that we are emphasising—that, under certain circumstances and in certain localities, the services of an expert guide are indispensable to safety. We happened, during a visit to Norway, to hear, as we slowly proceeded through one of the loveliest mountain regions of the interior, rumours that young Mr. F., son of a noted English photographer, who was taking photographs of the most beautiful points of view for the firm, had fallen into a cataract. At every stopping place we found that this tragedy was the chief theme among the people, and when we reached the spot where the accident had happened, we could not help deeply regretting that the natural impetuosity of youth, risking peril under the temptation so often yielded to by adventurous young spirits, should have robbed a fine young fellow of his life. And we happened to be in Constantinople when the chief talk there was about the mysterious disappearance of young Mr. M., son of a well-known London publisher, on the slopes of the Asiatic Olympus, near Brusa. When we crossed over into Asia Minor, and were in the district, we learned what particulars could be gathered, although the mystery was never solved, and the young Englishman was never again seen or heard of. He was ascending Olympus with a friend and a guide. The three had scaled one of the two peaks of the beautiful mountain and had descended. Mr. M. resolved to go up the other horn, and in his eagerness outstripped the guide and his companion. He vanished round some rocks at the foot of the peak, and unaccountably disappeared. It was supposed that some of the shepherds, many of whom occasionally act as brigands, had instantly kidnapped him, and that afterwards, when search was being made, under the auspices of both Turkish and British authorities, they made away with him in fear of the punishment they would have incurred. The lesson is a serious one. A guide should be followed, not led.

Not so Easy as it Looks. Nothing can be more misleading than a certain inference that the reader may easily draw by reading light and entertaining books of travel or articles struck off by expert magazine writers on travel. The idea is apt to steal over the mind while perusing some such specimens of very fascinating literature that many of the most risky feats are in reality devoid of all danger. For instance, many of Mark Twain's delightful sketches would make it appear that it would be simple fun, safely enjoyed, to wander anywhere and anyhow, at any hour of the day or the night, in great foreign cities or remote corners of distant lands. No notion could be more delusive. Even the most intelligent people frequently find themselves in a most distressing predicament through wandering off the beaten track alone in places where they are entirely strange to the country, the people and the language. There lies before us at this moment in the new issue of a magazine a very readable article entitled "Up the Matterhorn without Guides." It makes very pretty reading indeed, and it is true that the Matterhorn has been rendered much easier to scale than it formerly was, but there is not a sentence in this article to warn the inexperienced against the peril of attempting to emulate the feat described. It sounds ludicrously easy. The spirit of adventure is different from the spirit of ignorant recklessness.

The Little Things of Great Interest. One of the best modes of enjoying travel is to cultivate the art of noting the trivialities that make up by far the greater part of the details of life amongst any people. The talk of many tourists who attempt to describe what they have seen is altogether hackneyed and excessively tiresome, simply because they confine their sight-seeing to what is attended to by the overwhelming majority and has been described countless times before.

Take as an instance the fascinating city of Leipzig. Here we may study the very concentrated essence of the Teutonic spirit. Dear old Leipzig is Germany in epitome. Yet we know many people who have visited it time and again and have only seen it most superficially. They have never risen early in the morning to see for two hours before breakfast the wonderful popular life—the real life of the workers of

all grades in one of the busiest cities of Europe —which when once seen can never be forgotten. The dogs and the women dragging the little milk carts, the market "Frauen" pushing their quaint vehicles of vegetables and fruit along, the great wagons full of big rolls of fragrant, finely-dressed leather from the big factories, the troops of men and working girls hurrying along, the vendors of strange sorts of sausages, cakes, and other dietetic commodities unfamiliar to us, and, above all, the boys and girls in thousands passing to school, all of each sex alike beautifully dressed, and carrying their strapped knapsacks with books and food for the day—these are a few of the typical sights peculiar to the early hours of the day. Afterwards the mass of tourists are alert; but they have missed the spirit of the city. And we recall now, after a good many years, what an interesting glimpse we had once of the life of Lorient, "the French Portsmouth," where we arrived by road early one morning as the workers were streaming from the suburbs into the town. We caught more of the spirit of the place in that brief passage than a day spent in the conventional saunter about the main streets of the town would have afforded.

The Atmosphere of a Place. When Henry Ward Beecher was travelling, either in this country or on the Continent, he entered just in this style into the temperamental condition of every locality that he visited. He was on summer mornings always up very early that he might watch the common people in their proceedings. The "atmosphere" of a country is composed of the elements derived from the physical geography, the history, and the popular mind together. The nature of the country is formative of the habits of the inhabitants, and both should be studied if the profit and enjoyment are to be complete.

Copenhagen is a city of enchantment, but we know Denmark more truly if we not only see the capital, but wander awhile among the country people who are astonishing the world by their farming and dairy achievements.

The tourist will not know his New York very intimately if he merely rides up and down Broadway or Fifth Avenue, gazes at the skyscrapers, takes the trolley-car over to Brooklyn, sees a few theatres and churches, and indeed rides everywhere. He should wander on foot in China Town, in the great Ghetto district, walk about Brooklyn to see its incomparable, boulevarded, maple-lined avenues running for miles, take the steamer to Glen Island, survey the Bowery, linger in the wonderful Aquarium, peep into some of the congested foreign colonies along the sides of East River, feed in some of the common restaurants, and make some of the people understand that he really wants to learn something. They will tell him curious facts, and show him strange things, and he will understand the atmosphere, social, industrial, commercial, and political, of the vast city on Manhattan Island, and its huge overflowing annexes.

Our advice applies of course to travel anywhere. Where time is short, much may be seen in cursory passage and fugitive glance, if the mind is keen on receiving impressions, but where the traveller can halt for a longer stay, he must penetrate beneath the surface if he would learn many things best worth knowing.

Letters of Introduction. Those who take with them letters of introduction to personages resident in places to be visited are truly wise. How often have we ourselves proved the expediency of thus preparing for the best line of action. For example, when we landed at Smyrna on one occasion, we went promptly to a Greek gentleman settled in that city who carries on an immense fruit-packing industry, and owns many vineyards and orchards in Asia Minor.

Though to him we were total strangers, our letters to him from mutual friends in England won his kind heart instantly, and for a whole week he was at our disposal as much as we were pleased to avail ourselves of his boundless kindness. We remember that this gentleman was both amused and alarmed at the idea we had formed, amongst our other schemes, of taking some little excursions into the hinterland of Smyrna, which, with its mountains, looked so tempting. He drove us about the environs in his carriage, but explained that one of his most intimate friends had a few years previously, in that very region we wanted to penetrate, been captured by the notorious robbers of the interior, who had sent in to his friends for a ransom, which, heavy though it was, had to be paid in order to save the life of the citizen. Our Greek patron himself had never dared to venture amongst the lovely mountains yonder. But he made us wonderfully familiar in a few days with the chief city of Asia Minor, and thus we proved once more the advantage of seeking help in such fashion. He took care that we should really know the city where he lived and where he was one of the most influential citizens.

In European travel it is well to be a member of such an organisation as the Touring Club de France (5s. annual subscription), whose "delegates" are scattered all over Europe, and are always at the service of their fellow members, as we had proved on many occasions while travelling in out-of-the-way parts of France and Germany. As an instance of the value of this splendid organisation, we might mention that, desiring to make a cycle tour through the most beautiful and historic parts of Alsace and Lorraine the other year, we wrote for information to the delegate of the club at Saverne and that gentleman furnished us with several itineraries and the most elaborate, but extremely useful particulars of the roads, hotels, and so forth, inviting us to call upon him when we reached his own district, and placing himself entirely at our service; an offer we were delighted to accept in the true spirit of camaraderie. In many other towns the delegates of the Touring Club have proved equally obliging.

When to Visit Foreign Lands. The difference in the same country at different times of the year is in many cases astonishing. There are lands which it is the height of folly to visit at certain times of the year, while they are a

other seasons supremely attractive. Attention should by all means be paid to this point. A popular English minister of religion some years ago took a holiday of a few months, intending to pay a prolonged visit to the United States. Unfortunately he went just at the hottest time of the year. The consequence was disastrous. A latent heart trouble, which had been entirely unsuspected, quickly developed in the intense heat, and the preacher died in America. The "Indian summer," in late autumn, is the most delightful time of the whole year for travelling in the United States. The latter portion of springtide or earlier period of summer will be found almost as enjoyable. As to India, summer in the great plains is a purgatory, while winter is enchanting.

Climatic Conditions. Surely nothing is more important for the average traveller than the consideration of climatic conditions. For instance, we cannot imagine an Englishman enjoying the torrid conditions of Greece in the height of summer, when the whole land is a parched caldron. But in winter it is like a garden of the gods, and in spring the land is too beautiful, with its verdure and its flowers, for description.

October is a fine month for that country, as also for Turkey—European or Asiatic. The climate of Russia is glorious, and the "white nights" of the North are the joy of the traveller, although if he comes down south he will not conveniently bear the midsummer heat. A trip in Southern Russia is very enjoyable in September. This applies also to Austria and Hungary, to Servia, Bulgaria, and Roumania. As to Italy, that paradise in the Mediterranean has a strange variety of climates. Among the hill cities of the Apennines and in the charming resorts high up in the Italian Alps, and especially in Tyrol, we have revelled in every condition of comfort so far as the atmosphere was concerned during any part of summer. If we would find ideal summer joys we must succeed in our quest anywhere in Norway, Sweden, Finland, or Denmark. To Spain go in late autumn or early spring. Germany, Holland, Belgium, and France we may see with absolute pleasure at almost any season we like to choose, always remembering that the South of France and the whole Riviera are exceptions, for these delectable regions are semi-tropical in summer and swelter then in the breath of the sirocco, while in winter they call loudly for the invalid to patronise their health-giving resorts along a lovely coast bathed in delicious sunshine. Cyclists, however, should avoid July and August for long journeys in all of these countries. For nearly all the year Sicily is a dreamland of climatic luxury and of unearthly loveliness. And Capri is never either oppressive with the heat or repellent with cold.

Calculating on Local Conditions. We have alluded to the strange differences of climate that may prevail in contiguous districts. Any tourist may easily take advantage of these same differences. We remember how, when one summer, even though the season was growing late, the heat was intolerable in the region of the Italian Lakes. One day, in Brescia, we concluded that we would retreat out of the palpitating atmosphere to higher pleasure grounds. We took conveyance for Madonna di Campiglio, and there, in an elevated centre, where exquisite valleys meet and mountains soar up like Adamello and Spinale, with cool glaciers and purling streams everywhere in view, we found life worth living day after day, for we had ascended just 5000 feet. Again, on another occasion, we had a very similar experience in Switzerland, making a hurried retreat from sweltering Geneva to the lovely valley of Chamonix, where the cool nights tempered the summer atmosphere delightfully. Thus, the tourist who chooses localities for a summer trip where he can make his programme elastic enough to accommodate himself to convenient and desirable conditions is apt to be happily rewarded.

The Features of Other Lands. The special characteristics of various countries must surely enter into the consideration of a would-be traveller. He may wish to regulate his choice by some of these. No country is without individuality all its own, and this must have its influence. No country is so accessible for us in England as France. But people on this side of the Channel are generally little aware of the richness of the neighbouring nation in its architectural gems. It is a land of superb cathedrals, which strangely escaped destruction during the Terror. And, of course, when we are thinking of cities reconstructed in the modern style of supreme beauty, the mind at once flies to Paris.

Italy is the world's unrivalled art-gallery, from the lakes of the North to the extreme point of Sicily in the South. The visitor who roams about its cities, whether in the Apennines or in the plains, may despair of exhausting the marvels that have accumulated from Etruscan days down to our own times. Greece is the very shrine of history, and a sojourn in Athens and Corinth, in Nauplia and Patras, will make any traveller feel that he had indeed added an invaluable course to his education. Germany is truly called "the brain of Europe," and it is at this moment more worthy of attention on the spot than ever, for there the country is being turned into a veritable laboratory of economic and industrial practice, working out the most advanced theories of the savants.

For glory of scenery, Switzerland is naturally peerless, but it is worth personal study as the home of the happiest community in the world. Holland and Belgium make any holiday delightful because of their perfect presentation of the quaintest charms of Mediævalism. Norway, with fjord and fjeld, brings us to the gateway of the Arctic, and is the finest European field for adventure and romance with the minimum of peril. Egypt is the casket of the hoariest antiquity.

And so each land has some pretension to particular merit, and each will amply reward a preferential choice that may happen to fall to it in the traveller's decision.

Group 26

SHOPKEEPING

3

Continued from page 279

THE SCIENCE OF THE SHOP FRONT

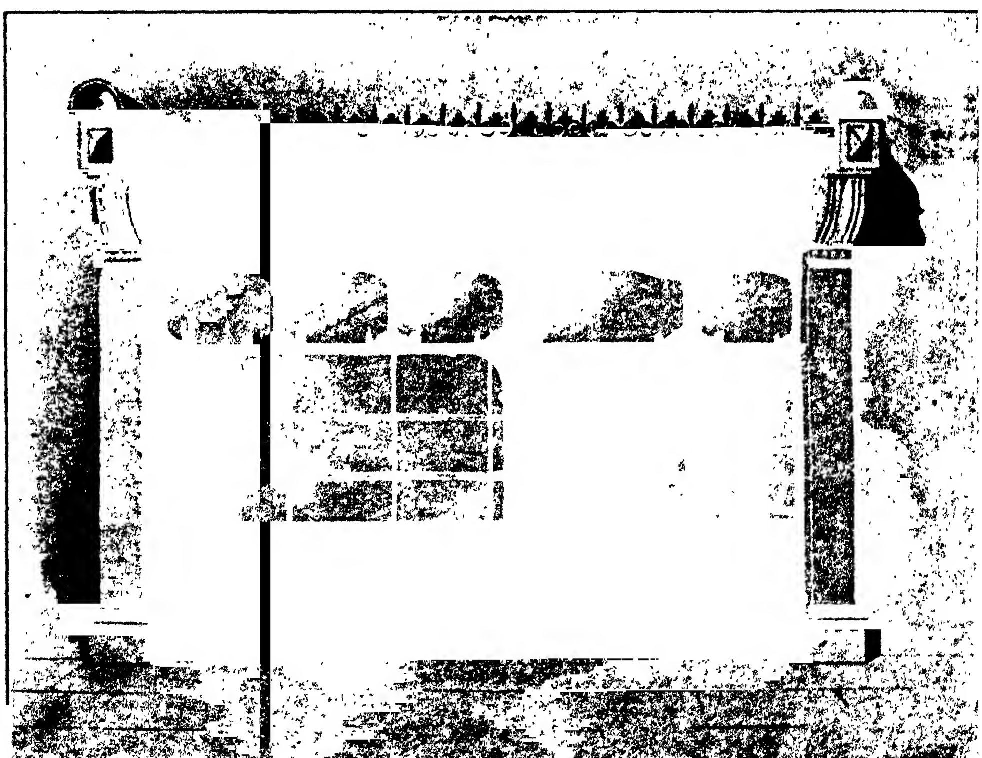
A Question of Vital Importance to all Shopkeepers. The Value of a Good Front, and the Considerations Affecting it

By W. B. ROBERTSON

The Scope of the Shop Window. The business man who neglects his shop window is as culpable as the soldier who allows his rifle to become foul or his sword rusty. The shop window is the chief medium through which an impression may be made on the public, the principal bait to draw fresh custom. George Chapman wrote, "Keep thy shop and thy shop will keep thee." We venture to make the statement a little narrower, and to offer as a sound business maxim: "Keep thy shop window attractive and thy shop will keep thee." Not that an attractive window display is the single essential to a successful business. It is, or may be made, nothing more than the most effective agency in drawing strangers to the counter. The quality of the wares and the manner of service must decide whether or not business will result.

In these days of twentieth century competition, when the ability of shopkeepers to provide articles of consumption, use and ornament is greatly in excess of the purchasing power of the public, the growth of any business must depend largely upon the success of its proprietors in attracting the customers of competing trade men. To look around us in mental survey and to consider those tradesmen whose operations have exhibited progressive increase in number and magnitude is to acknowledge that the successful men are those whose window displays are features of their business practice.

Analysis of the conditions which go to make a successful window display shows that they naturally divide themselves into two classes. First there is the shell of the window, the shop front, and, secondly, there is the contents and their arrangement. Many shopkeepers spend



1. AN ARTISTIC BUT INEXPENSIVE SHOP FRONT

a good deal of time and money on one or the other, but not on both. Their sins of omission in one department more than neutralise the work and value they have put into the other. In any street in any city in Great Britain it would be possible to find shop windows with expensive fronts and soiled or carelessly arranged contents. The effect is as incongruous as when a choice sample of the milliner's art surmounts a grimy face. This fault is much worse than that of a window with a poor shell and a tastefully-arranged interior. Excellence in both departments gives us the ideal—and the successful shop window.

The Shop Front. We would first give some attention to the shop front from both the artistic and utilitarian points of view. What a transformation in the shop fronts of our city streets the last generation has witnessed! The security of the shop was formerly thought to depend upon the solidity and the impermeability of the front. We had shops protected as were the hulls of Nelson's battleships—heavy iron-plate shutters and doors, bolts reaching from floor to ceiling. Now light takes the place of iron plates and bars. Windows with large expanse of glass, protected only by spidery grills through which the interior is visible even by night, are undoubtedly the most secure as well as the most attractive form of shop windows which the retailer can adopt.

The shop front should be in harmony with the class of trade in which the shopkeeper is engaged. The light and artistic front which we admire in a jeweller's shop—and which we also expect, though not in quite so pronounced a form—in a confectioner's or a draper's shop, would be out of place in a builder's, an ironmonger's, a butcher's, or an oil shop. The nature of the trade, whatever it may be, should find expression in the form of the front.

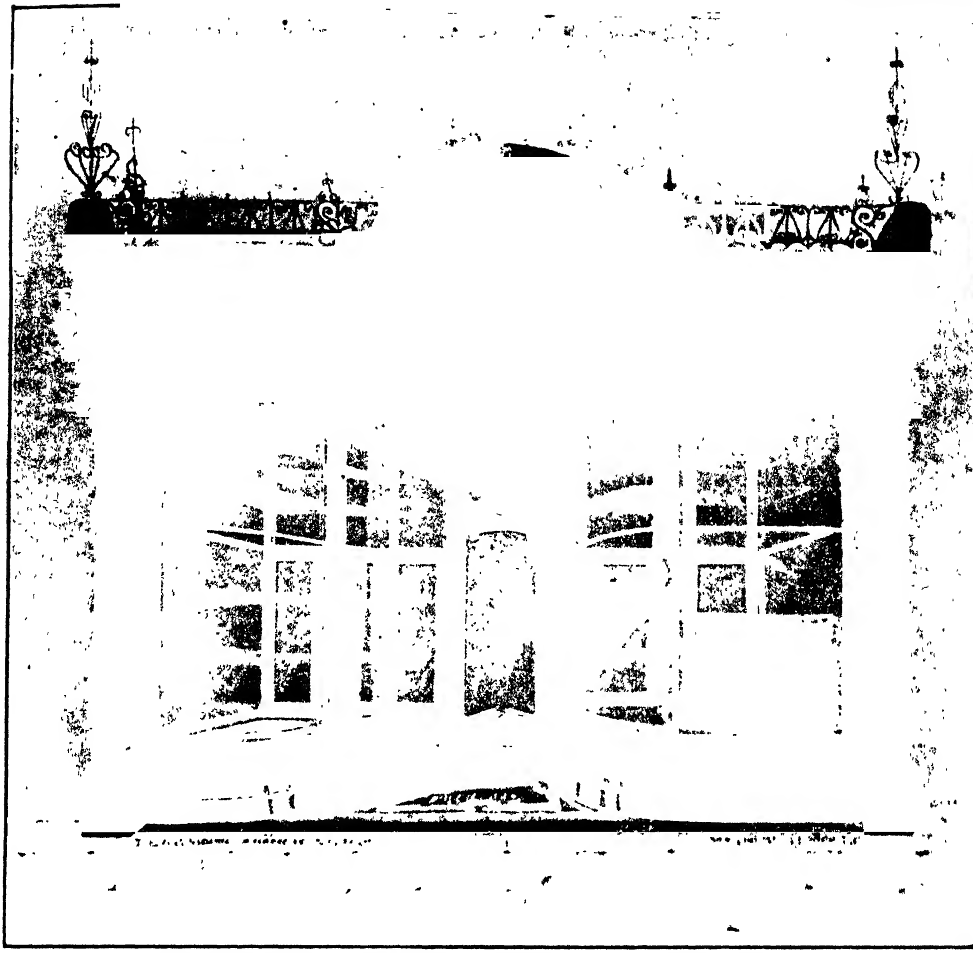
A Shop Front as in France. We know of no class of shop where the trade is advertised by the front so thoroughly as it is in the paint and oil shop of France and some other European countries. Almost invariably the entire front of the shop building is planned in radial segments in which all the colours of the spectroscope are depicted. The shops are masses of paint patches and indicate the nature of the business more plainly than the hues of Joseph's coat indicated the personality of the wearer. We have not observed that any English painter and colourman has copied the practice of his French fellow. The plan is so practical and so appropriate to the trade concerned that few people would find fault with it. It might be objected to from the æsthetic point of view, and we confess that sometimes there would be some reason in the objection. Frequently the primary and secondary tints chosen are rather strong to be pleasing, and we believe that the more general employment of neutral tones would serve the purpose as well without violating one's sense of colour harmony. But the practice of the French oil and colour shop is one which the British retailer might introduce in a modified form.

Counting the Cost. A shop front of some pretensions to elegance costs a little more money than a plain one. The higher cost is often the reason for the installation of the less attractive form. If consideration of the question be based upon true principles of business economy, it is well, and it may be that wisdom has been shown in selecting a common, cheap shop front. But the true principles of business economy are not always placed in the witness-box when adjudication is being made.

To help us to understand the expenses incurred by a special shop front, a prominent firm of London shop-fitters have supplied us with two designs which they have recently executed. One is for a baker and confectioner, and the other for a jeweller. The former [1] was executed in mahogany. The space available was 18 ft. wide by 11 ft. high to the bottom of the facia. The cost of the front only, made, fitted into position, glazed, and finished, was £90. The disbursement of such a sum for such a purpose should be decided by the question of prospective profit.

Less than a Shilling a Week. It may be assumed that a common shop front would cost not less than half of this sum, so that a front of the design we illustrate would entail an increase of £45 in expenditure. That is capital expenditure, and the interest on the amount at 5 per cent. per annum would be 45*s.* per annum, or just under 10½*d.* a week. The baker or other tradesman to whom the question presents itself, and whose establishment would be rendered more attractive by a specially-designed and executed front, has to consider whether or not the difference is worth, as a paying investment, the sum of 10½*d.* per week. We think that, put in this direct and practical form, the answer would seldom be in the negative. The internal fittings of the shop window we illustrate cost about £35. We did not include these in the simple financial problem just presented, and rightly so. These internal fittings would have been necessary, or at least desirable, in any event. They included air-tight glass show cases, glass shelves, brass standards and brackets, and tiled surround. In this particular case their expense was more than repaid by the preservation of the confectionery through being protected from atmospheric influence and dust.

Importance of the Window Frame. When the expenditure of a few pounds extra in the erection of a shop is a barrier to the installation of both a good front and good internal fittings, it is advisable to decide upon the former in the first instance, leaving the latter until such time as funds may warrant the disbursement. It is a small matter to replace internal fittings, whereas to tear out a front and replace it with another is a much more serious and costly business. In 2 is illustrated another shop front of special design, which we reproduce for two reasons. It shows a front of greater pretensions than that to which we have just given attention, and incidentally it teaches how available window space may be made apparently much wider by a simple trick of design. In this par-



2. AN ARTISTIC AND EFFECTIVE DESIGN FOR A NARROW FRONTAGE

ticular case the shop was for a watchmaker and jeweller. The space to be filled was only 16 ft. wide by 11 ft. high to the bottom of the facia. The work was carried out in mahogany, and the total cost, including all the special air-tight window fittings most suitable for the trade, was between £250 and £300. Assuming the higher figure as the price, computation upon the basis already indicated shows that the interest on the capital sunk would be less than one shilling a day. A jeweller considering plans for a shop would have to consider if a front, window, and window cases of the class illustrated would be worth a shilling a day as a business investment, and in any town except the very smallest, we fancy that here, again, there would not be much doubt of the decision.

The space available in the case before us was, as already stated, exceedingly narrow, only 16 ft. between the pilasters. The manner in which the utmost has been made of this space deserves attention. The circle given to the glass—on one side of the door a convex circle, and on the other a concave and convex—made the window front much wider than it would have been had the more common design been adopted. Had both sides circled outwards, spectators would have been likely to block the doorway to a much greater extent than with the convex and concave form shown in the design.

Points for and against the circled glass in the shop window are that it is much stronger than ordinary flat rolled plate, that it costs much more, and that it is often extremely difficult or impossible to replace a broken window speedily. When circled windows are fitted, it is always advisable to purchase and store duplicate panes, so that immediate replacement is possible in the event of breakage.

Window Cases. The nature of the window interior depends so much upon the trade and the goods to be shown that a general consideration cannot descend into minute detail. Any arrangement should never lose sight of the frequent need of withdrawing and replacing exposed articles. The difficulty of extracting

individual articles from the window sometimes causes retailers to establish a rule that no articles be sold therefrom. This is always bad. Refusal to sell from the window breeds in the mind of the would-be purchaser a suspicion that the goods sold over the counter are not of the same quality as the window samples. The shopkeeper who values a reputation for frank and straight dealing should make a profession of willingness to withdraw any article from the window upon request, and to enable him to do so he should have his window fittings arranged and his windows dressed so as to permit him to do so with the least possible inconvenience.

Air-tight glass cases are usual in the shop windows of many trades. They are valuable in preserving the goods shown from deterioration by atmospheric influence, but they have their limitations. If they must be opened very frequently they are of little practical service. Every time the doors swing back the cases become part of the shop and any fog or humidity which may permeate the atmosphere finds its way to the merchandise. Therefore, while air-tight cases are always desirable for delicate or tarnishable goods, their full value is secured only by refraining from opening them. This looks like a contradiction to what we have just said, and it is so. The shopkeeper must sometimes choose between refusing to sell from the window and having his window stock preserved untarnished.

It may be possible to mitigate the bad effects of opening a large window case by having the window partitioned into separate compartments individually air-tight. This is possible, for instance, in showing electro plate, and sometimes it is well worth the extra initial cost.

The Value of Mirrors. The value of reflection by mirrors in window displays is not appreciated as it ought to be. When a window is narrow and deep, the effect which one or more mirrors can lend is a great acquisition. In such circumstances the introduction of the mirror is most desirable, and there is no window which could not be made much more impressive if mirrors were made permanent or temporary features of the window displays. The mirror is most effective in a divided corner window. Placed at an angle in the window it catches the eye of the passenger and the window or the half of the window is made to appear double its actual size. Where mirrors are used, a flat scheme of window dressing should be adopted. If the arrangement be high in the front the mirror is robbed of its opportunity to do its full duty. A mirror placed so that passengers may see their own reflection usually causes many passers-by to stand and gaze. "Vanity of vanities, all is vanity, saith the preacher," and the preacher knew what he was talking about.

The mirror has an attraction not for the fair sex only. We have stood for fifteen minutes near a London window which held a mirror in a prominent position. We counted the respective numbers of each sex whom the mirror arrested, and the proportion was seven ladies to ten men, notwithstanding that the lady promenaders far outnumbered the men. We have seen a mirror of a special kind used to good purpose in a barber's window. It was a concave mirror, and therefore magnified. Placed close to the front glass of the window, it impressed the man whose habit was to shave every second day with the desirability of doubling the frequency of the operation, and it persuaded the man who had developed the practice of being his own barber that the task was one he performed badly The barber took a larger shop in a few months.

The Value of Light. It is common, in the shopping thoroughfares of our large towns, to see one shop stand out conspicuous among its fellows by the blaze of light which issues from its windows. The proprietor appreciates the value of light as a business agent. Indulgence in advertisement by light is expensive, but, judiciously used, it is remunerative. Sometimes the facia of the shop is surmounted by a profusion of gas jets. This is not a practice to be commended. It is extravagant, unremunerative, and foolish. The light should be focussed upon the goods displayed in the windows, and not sent out purposeless into the night. Perhaps the most conspicuous object lessons in the value of window lights are the shop windows of the vendors of imitation diamond jewellery, which are, at the moment of writing, finding an apparently lucrative field of enterprise in the large towns in England. The lights in these are usually incandescent electric, and they are generally numerous and concealed from the direct observation of the window-gazer. If they are aided by revolving pedestals covered with black or blue velvet, and mounted with paste wares, the sparkle emitted from the tiny polyhedrons of glass is fascinating. The public does not wait to consider what gives the effect, and is often induced to spend money upon such ornaments in the belief that no one will detect their falseness under ordinary conditions.

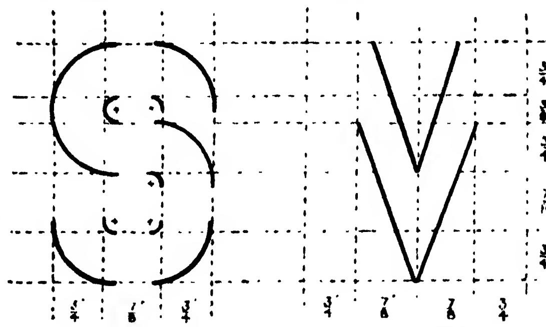
Electric Light. Many lighting mediums lie at the choice of the shopkeeper. The electric light has a great deal to recommend it. The electric arc light, however, should never be used. It is concentrated in one point or in very few points, and therefore throws shadows which should be avoided. Incandescent electric lamps are much better. They may be diffused throughout the window, hidden in any corner and arranged so that no shadows are cast. They do not throw off the products of combustion or the great heat of gas jets or incandescent mantles, and thus do not exercise the deteriorating influence which gas flame does upon almost every class of exposed merchandise. The objection to electric light is its high cost.

The disadvantages attending the burning of gas in a window are sometimes averted by having pavement lights—*i.e.* lamps suspended from above the window and throwing illumination into the window. These should be adopted only when the window is high. In any case, they are apt to throw the shadow of the window-gazer upon the contents of the window.

Taking into consideration every class and

method of application of window-lighting systems, that employing incandescent electric lamps is for every reason the best, and should be adopted wherever available if cost be not an insuperable barrier. Not the least of its advantages is that lamp holders may be placed in any position.

Window Steaming. How to cure window steaming is a problem that has exercised the wits of many shopkeepers, architects, and heating and lighting experts. The sovereign remedy, acceptable from every point of view, has yet to be found. Nothing is more objectionable than condensation on the shop window pane. It is caused by the difference between the external and the internal atmospheric temperature. The only thorough method of obviating it is by a system of ventilation, allowing the external air to circulate into the window, but the objection to this is that dust also penetrates, soiling the exposed goods and filling the window with deposit of extraneous matter. Several preparations, mostly of a glycerin nature, have been offered from time to time, but they are at best only partially successful. A remedial measure, efficient but expensive, is used in many large shops. A Bunsen burner, or several of them, are kept burning at the bottom of the window near the glass, and the steam of hot air which they send up close to the glass prevents the condensation.



3. HOW TO CUT OUT WINDOW LETTERS

Window-pane Legends. The introduction of the enamelled letter introduced a new feature into the shop windows and for a time the enamelled letter legend on the shop window-panes was painfully in evidence. Too often the cement which had been used to cause the letters to adhere had failed in its duty, and the result of dropped letters was often ludicrous and always unsightly. Improvement has been made in the cement used or in the method of its application, for we do not now see the mutilated words that used to constitute a guessing competition as to the dropped letters in every street. A letter with small diamonds or circles of coloured glass was recently introduced to the notice of shopkeepers. Its value lies in the fact that the light shines from the window through the letters in the evening. From this point of view the new style of letter may be acceptable, although in daylight the plain white letter looks better. But plain and ornamentally glazed letters should never be introduced into the same sign or word, although we have frequently seen it done.

The disadvantage of permanent window letters is that seasons goods cannot well be advertised by their agency. Sometimes a simple but inexpensive expedient is adopted to overcome this disadvantage. A little skill, experience, and ability to use a compass and square will enable anyone to cut from white paper letters perfect in form which may be attached with mucilage to the inside of the window, and which will deceive any casual observer into the belief that they are enamelled letters. Any smart assistant may easily acquire the method of cutting these letters. The accompanying sketch of two letters [3] will show the mode of marking off for cutting. It may be well, after a complete set of letters has been cut, to have duplicates made in zinc to serve as models for any that may be required subsequently, and thereby save the labour of marking off again. Great care ought to be taken to fix the letters straight on the window. Few things look worse than lack of proportion or misplacement of the letters, and they should be removed with the passing of the season, as to advertise an article out of season is foolish.

The Sign-board. The trading name and the nature of the business ought always to be displayed in plain bold letters above every shop front. Prominence is no excuse for neglect of this requirement. How often have we seen shops with the plain legend "Smith & Co.," or whatever the firm's style might be. Smith & Co. might sell watches, or sausages, or any other merchandise for all that the shop exterior indicates.

Plain Roman letters, or one of their modifications, where art has not interfered with legibility, should alone be adopted. Look down the shop signs in any village street and one may see written large what sort of a man the village painter is. He usually affects the style of letter he can paint most easily, and it is often a hideous thing of blobs and fish-tails that attempt to hide much disproportion.

When the shopkeeper is not quite steady in his orthography and the painter even worse in this respect some marvellous signs are often the result. The particular form of originality usually taken in such a case is in the profuse use of the apostrophe. We have *café* written *caf'e*, and every plural noun rendered in a possessive form. The punctuation of the sign is often bad. A full stop should attend all abbreviations, and should be placed at the end of the sign, but there should be none between the two words in such a name as John Smith. Different varieties of lettering should not be permitted upon a window or shop sign. Uniformity shows good taste.

To be continued

Group 5
CHEMISTRY
3
Continued from page 241

THE RELATIONS OF THE ELEMENTS

The Periodic Law: its Meaning and Power of Prophecy. Are the Elements Truly Elementary? The Atom

By Dr. C. W. SALEEBY

A Brief Recapitulation. In the first half of the second lesson, as the reader will remember, reference was made to the future of chemistry in various practical and theoretical directions—a subject which naturally came up for consideration after the historical study of the first lesson. Even in those introductory parts of our subject it was necessary to speak frequently of elements—especially the discovery of new elements in the early days and also in recent times. Thereafter it was necessary to come to somewhat closer terms with the idea contained in the word elements: and reference has been made to the fact that the *periodic law* has already forced chemists to the conclusion that the elements are related, but that we cannot accept the simple view that the atoms of all the other elements are compounded of atoms of hydrogen. Thereafter reference was made to some of the principal elements, including those that make up a large part of the earth's crust, and also to the metals, which are dealt with in the special course METALLURGY.

We must now take up seriously the matters already referred to—the relations of the elements and the periodic law. We have by now had sufficient illustrations of the general proposition with which we started—that matter is of different kinds. We have seen that some of these kinds present obvious differences, while others are hard to detect from among their neighbours. We have seen that some of these kinds occur in large quantities in the *free state*—that is to say, not compounded with each other. We have also seen that some of these kinds are very abundant, whilst others are exceedingly rare, and we have made some reference to that group of kinds, long thought to be specially distinctive, which are known as the metals. And now our first concern must be that statement of the relations of the elements to one another which is known as the *Periodic Law*, or the Law of Mendeleef.

The Periodic Law. Ever since men began to arrange the different kinds of matter into groups or tables of elements, they have suspected that there exists some kind of a relation between one element and another, a relation none the less certain because it was impossible to say exactly in what it consisted. Reference has already been made to the suggestion, based on the relations of the atomic weights, that all the other elements are simply compounds of hydrogen. That, however, could not be accepted; nevertheless the study of the various atomic weights led chemists to the conviction that there must be some relation between the elements, even though it might not be so simple as had been suggested. Then, again, it was observed that from the various elements there could be picked out little groups of substances which resembled one another—for instance, Chlorine, Bromine, and Iodine; or Calcium, Strontium and Barium. The members of these groups resemble one another in singular degree, but this in itself was not sufficient to excite much comment. The point is that in these and in other cases, if we add together the atomic weights of the first and the last members of the trio and then divide the result by two, we obtain almost exactly the figure corresponding to the atomic weight of the intermediate member of the trio. This suggested that in each trio there was a sort of regular stepping forward in the complexity of the atom from the lightest member to the heaviest. So far there was merely probability and suspicion in favour of the view that in reality there is only one element; but a great advance was shortly to be made.

The Work of Mendeleef. Omitting the names and the contributions of lesser men, we may pass at once to the great discovery of Mendeleef, which will make his name immortal. This great student of nature, still alive when these words are written, is by far the greatest of all chemists yet produced by Russia. He was born 1834 at Tobolsk, in Siberia, and was the youngest of a family of seventeen. In 1864, when he was thirty, he became professor of chemistry in the University of St. Petersburg, and has occupied that chair ever since. We may ignore Mendeleef's other work and may confine ourselves to his discovery of what he called the *Periodic Law*. We are about to consider the grounds upon which the assertion of this law is based; but meanwhile we may note the remarkable manner in which the law has been vindicated by means of its power of prophecy.

The reader will remember the instance of the manner in which the law of gravitation enabled astronomers to predict the existence of a planet hitherto unknown, in consequence of the disturbances in the movements of the planet Uranus: thus they were enabled to discover Neptune. Similarly Mendeleef illustrated the truth of his Periodic Law by stating that there were certain gaps in the list of the elements as stated by chemists in 1871. In that year he asserted that there must be three new elements which the chemists had not yet discovered. He actually ventured to give them names suggestive of their affinities, to state their atomic weights, to describe some of the properties of their compounds and the colours of their salts. He called these elements Eka-Boron, Eka-

Aluminium and Eka-Silicon, and within fifteen years the whole of his prophecy came true. One of his predicted elements was discovered in the year of the prophecy, another eight years later, and the third in 1886. They are now known as Gallium, Scandium and Germanium. Not content with this most amazing of successes, Mendeleef frequently dared to assert that the atomic weights of certain of the elements as usually asserted and accepted by chemists must be incorrect, because they did not "square" with his theory.

Laws and Facts. Now, before we note the result of this piece of apparent presumption, let us permit ourselves a digression to observe that nearly all of us resemble Mendeleef so far. We have got a theory with which some facts or other do not tally, and we reply with the Frenchman, "Tant pis pour les faits"—so much the worse for the facts. This is the spirit which, perhaps above all others, except, of course, the spirit of acceptance of authority, has interfered with the progress of Science; but it need hardly be pointed out that in Mendeleef's case there is a fundamental though not very obvious difference.

Mendeleef had inferred, from a large number of accepted facts, a certain law. That was, of course, a typical case of what is known as inductive or *à posteriori* reasoning, the typical method of Science. Then, having reasoned backwards from the facts to the law, Mendeleef was enabled to reason forwards from the law to new facts by a process of deduction or *à priori* reasoning; but the facts that he thus deduced did not answer to the facts that had been stated by chemists as the result of actual observation. He therefore requested chemists to set to work to make their observations over again. He said, in short, concerning elements, which perhaps he had never himself seen. "There was something wrong in the manner in which you weighed this substance; weigh it again and you will find its weight to be not 30 but 31." Well, the chemists set to work to obey orders and found that Mendeleef was right.

Scientific "Law." This is an instance, like the discovery of Neptune, of the legitimate use of the *à priori* method in science; but supposing the atomic weights had been found to be not what Mendeleef—assuming the truth of the Periodic Law—had asserted, then the law would have had to go. What we call a *law* in science is, in the first place, a generalisation from, or a generalised statement of, a number of facts; but when we call it a law, we assert that it will cover more facts than those we have actually observed. At any moment such a law must be upset if there arrives a fact with which it is incompatible. We may remember Huxley's joke as to Herbert Spencer's idea of a tragedy: "A deduction killed by a fact."

Some twenty years after the enunciation of the Periodic Law there was discovered a series of elements, beginning with Argon and including Helium, Krypton, Neon and Xenon, which seemed to have no place in the periodic system, and which—had this suspicion been confirmed—would have sufficed to have upset the Periodic Law, since any deduction may be killed by a fact. But when the atomic weights of these five new elements were ascertained, it was found that they fitted perfectly and in due sequence into the periodic system just as well as if the great discoverer had constructed his theory with reference to their existence.

Evidence for the Law. Let us now consider the nature of the evidence upon which Mendeleef based this now universally accepted statement of the Periodic Law. There were already known the facts concerning the trios which we have named, and also the fact that a great many of the atomic weights could be reckoned as whole numbers, thus implying a relatively simple relation to one another. It was an Englishman, John Newlands, who set Mendeleef in the right direction, by showing that if the elements are arranged in the order of their atomic weights in a series of lines written from left to right in the usual way, and if the table is then read downwards in parallel columns, we find that the elements of any column resemble one another. In other words, it amounts to this, that the really essential and fundamental fact of an element is its atomic weight: all its other properties, down to the nature of its compounds and their colour and solubility, could be inferred, if we knew enough, from this one given fact, the atomic weight of the element. Mendeleef, as we have seen, has already proved that a great many facts can be thus inferred.

Its Most Abstract Statement. We may then assert that the properties of an element are a function of its atomic weight. This is not all, however. It is not merely that the elements may be arranged in a single series in the order of their atomic weights, and that they then display a simple sequence in their properties. On the contrary, there is a recurrence, or a zig-zag, if one reads the list of the elements in such a fashion; and this recurrence or periodicity is displayed when we arrange the elements in columns, as has been already shown. Hence we must say more than that the properties of an element are a function of its atomic weight, and must insert another very important word, thus: *the properties of an element are a periodic function of its atomic weight.*

As the weights of the atoms of the elements rise, there is a periodic recurrence of their properties. It scarcely matters what property is taken, we find that it alternately increases and decreases as we pass from one end of the list to the other. Again, it is found that the elements of the tops of the curves—if this periodicity has been diagrammatically expressed by a sinuous curve—resemble one another, those half way down the hills resemble one another, and so forth. So recently as 1904 the veteran chemist of St. Petersburg—retaining, like most men whose lives are devoted to science, his intellectual vigour at an age when the average man is in his dotage—discussed at length the evidence for the law which he had discovered in

his youth, in the light of the recent facts which have been accumulated by chemistry; and he was able abundantly to demonstrate that the law does indeed correspond to the truth. It is as entirely compatible with the thousands of facts which have been discovered by chemists since 1871 as with the few facts which Mendeleef had predicted.

Meaning of the Law. Granting, then, that the law is true, and that it is a means of discovery and of suggesting the directions in which observation has erred or in which it should be extended, we must go much further and enquire as to the meaning or significance of the law.

If we return to the more or less suitable analogy furnished by the law of gravitation, we shall be able to understand what is meant by our search for the real significance of the Periodic Law. The fact of universal gravitation does far more for us than merely enable us to discover new planets or correct our ideas as to the movements of old ones; it teaches us that the whole universe, as we know it, is really one, and it leads us to the irresistible conclusion that the apparently complete separation between the various heavenly bodies can be only apparent, that they must all be joined together by means of a subtle medium none the less real because it happens to be invisible.

Similarly the Periodic Law of Mendeleef does far more for us than enable us to discover new elements or correct our notions as to the properties of the elements already known; it teaches us that all the elements are really forms of one element, and it leads us to the irresistible conclusion that the apparently complete distinction between them is bridged by a real medium of continuity. The analogy, perhaps, is not a bad one, for the ether which is regarded as the medium of communication between all the heavenly bodies is now also being regarded as the *Mother of matter*—the common source of all the different elements.

This, then, is the real interest of the Periodic Law, that it urgently suggests so definite a relationship between the atoms that we are compelled to regard the elements as not elementary, but as expressions of one element.

The Atom not really an Atom. More strictly the law suggests, indeed it proves, that the atoms are not atomic or "uncuttable," but that they must be made up of parts which in the successive atoms of any group of elements must be multiplied or jointed with one another in a regular and definite fashion. In fact we find an extraordinary parallelism between the atomic weight and the molecular weight. When we turn to the chemistry of the carbon compounds we shall see that there are any number of series of compounds which form definite groups, having a regular difference beween the molecular weight of each two compounds in the series, and having this regularity explained by the fact that each compound contains, for instance, one atom of carbon and two of hydrogen more than its predecessor. The relationship between the members of such a group is explicable upon the assumption that the members are compounds made up of parts which we call atoms.

If we turn, then, from such a series to a series of "elements"—so-called—that form a group under the Periodic Law, we find an almost exact parallelism. There is the same increase in atomic weight and the same regular change in visible properties as are illustrated in many instances from the chemistry of the carbon compounds. Are we not, then, forced to the same explanation: that just as the molecules of these compounds had their relationship explained by the assumption that they consisted of similar parts—the atoms—so the relations between a series of atoms may be explained if we again assume that these also consist of a series of like parts, which are the atoms of the atoms. This is the unavoidable conclusion to which the Periodic Law points us, and this it is that gives it its deep significance. But at this point the law leaves us without further guidance and with no prospect of it. Most positively the law tells us that the atoms of the elements are made up of regularly varying combinations of a unit more atomic and more elementary than any known atom or element, but when we enquire what is this unit, the law can give us absolutely no answer. No further amount of study of the law can do anything more than tell us that such a unit must certainly exist, and for a knowledge of the nature of this unit, to which the law has directed us, we must adopt a wholly new set of experiments, methods and observations.

Chemistry and Physics. This, indeed, is one of the many places where chemistry and physics must have recourse to each other. So far as the resources of chemistry are concerned we have reached a deadlock However long we continue to weigh, analyse, measure, and compare the various kinds of matter, there is no hope of discovering the common unit, the *true* atom, of which they are all composed. Chemistry, in virtue of the Periodic Law, merely asserts that there *must be* such a unit. On the other hand, physics could never have reached such a conclusion by itself. Physics, in studying matter under certain peculiar conditions—as, for instance, the behaviour of matter inside one of Sir William Crookes's vacuum tubes—can assert that there must be a "fourth state of matter," in which it is neither solid, nor liquid, nor gaseous. Physics can even go so far as to assert that matter in this fourth state must consist of minute particles of uniform size, which are distinguished by carrying each a tiny charge of negative electricity. But physics alone could never declare that *all matter* is so constituted. In order to reach this conclusion, by far the greatest achievement of science during the last decade, it was necessary for physics and chemistry to co-operate, and that is what they have successfully done.

To be continued

Group 7

CLERKSHIP

3

Continued from page 195

KEEPING THE BOOKS OF A SMALL FIRM

The Work of the Junior Clerk. Commercial Terms and Abbreviations. Weights, Measures, and Coinage Systems of the World

By A. J. WINDUS

Books of the Junior Clerk. As for what is termed single-entry bookkeeping, it is really almost beneath our notice. Were it not for the fact that, as we shall see, there is very little genuine single-entry bookkeeping, and that much of what passes for such is a mixture of single and double entry, we should scarcely need to waste further time on it. Examiners in bookkeeping are, however, very fond of setting, under various guises, the question, "What constitute the chief points of difference between single-entry and double-entry ?"

This will necessitate our devoting a future paragraph to the matter, but in the meantime let us suppose that we are dealing with the books of a small firm of merchants trading in the City of London, and that these books are kept by double entry. The business as yet does not need a large staff, and so the office-boy, while still retaining the Postage Book, has been entrusted also with the care and expenditure of the Petty Cash, has had his salary improved, and is now known as the junior clerk. Most of the duties of his former post have fallen to the lot of the boy in the showroom, who, if he is a capable youth, will some day become a salesman. The junior clerk has other tasks to take the place of those he has given up ; but let us first of all examine the book in which he records his petty cash transactions. Here is a specimen opening or folio ; it is called a *folio* because the number (58) appears on both sides of the opening. Had the right-hand number been 59 we should have spoken of the right-hand side as *page* 59, and of the left-hand side as page 58. The table represents Messrs. Bevan & Kirk's Petty Cash Book, with the entries therein from September 20th to September 30th, 1905. Let us consider the uses of this book.

The Petty Cash Book. First, the cash in hand may be checked at any moment. For example, the junior clerk started the day on September 20th with a balance in hand of 13*s*. 1*d*. How do we know this ? By merely subtracting from the total amount received up to that date the total amount paid away (£60 10*s*. 0*d*. – £59 16*s*. 11*d*. = 13*s*. 1*d*.). Of course, if there is more or less than this in the till, or in the cash-box, some mistake has been made, and it is the clerk's duty to discover it. To avoid the risk of errors and omissions remaining undiscovered, it is advisable to count the cash in hand at the beginning of each day, and to compare the result with the figures in the Petty Cash Book. Thus, the balance at the beginning of September 25th, according to the book, was: Receipts, £60 10*s*. ; *less* Payments, £71 16*s*. 2*d*. —that is, £8 13*s*. 10*d*. But when the clerk tested this with the money in the cash-box he found only £1 13*s*. 10*d*. in coin and an I O U for £7.

Received.	Date 1905.	Particulars.		
60 10	Septr. 19	Brought Forward . . .		
	20	Postages		
		Telegram Jones 7½*d*., Ink 6*d*., Carman 2*d*		
	21	Fares, West End 8*d*., Wire to Smith 1 0½		
	22	Fine on letter insufficiently stamped .		
	23	Salaries and Wages (as per Salary Book)		
		Gratuities 6*d*., Fares 4*d*., Carr. on Samples 1		
	25	Pcls. Post, Williams Bros., Cape Town		
		Postages 5/-, Fares 6*d*., Paper fasteners 3*d*		
	26	Pcls. Post. Trading Co. of Madagascar		
	27	Advt. for Salesman 3/- Brown paper 1 9	4	9
	28	Travelling Exps. Mr Bevan's trip to M	3	8
	29	Telegrams : Jones 8½*d*., Smith 6½*d*. .	1	3
	30	Salaries and Wages	9	
		Gratuities 6*d*., Pencils 4*d*., Labels 1 - .	1	10
		G.L.2	13	11
		Balance, carried forward . . .	16	1
			10,	

The reason was that on the 23rd, when, as we see, an extra large amount of £15 was drawn in anticipation, Mr. Bevan borrowed £7 from Petty Cash as he was going to Manchester on a business trip, and gave the junior clerk an acknowledgment in this form:

I O U

£7,

WM. BEVAN

On the 28th, having returned from Manchester, he gave the clerk a note of his expenses, which amounted to £5 3*s.* 8*d.*, and paid back the unexpended balance of £1 16*s.* 4*d.*, whereupon the clerk entered the former amount as Travelling Expenses, and delivered up the I O U to Mr. Bevan to be destroyed. Thus the £7 originally borrowed has been duly accounted for.

Keeping the Balance. We have seen that the balance at the beginning of the day on September 20th was only 13*s.* 1*d.* The junior clerk wisely decided that he would require more money before the day was out, and obtained £5 to go on with. Notice in passing that the date column serves for both receipts and payments; accordingly £10 in the left-hand column is placed opposite the date September 30th, which means that it was received on that day. Observe, moreover, that when one or both of the date columns are blank the date immediately preceding governs; thus, having started our date column with September, it is understood that all the entries which follow are in September, unless otherwise stated. Again, although no date is placed opposite the last entry we know that September 30th is intended because that is the date immediately preceding.

If we inquire whence the money comes which the junior clerk receives for petty cash, we shall find that the whole of it comes from the bank, with the apparent exception of an amount of 10*s.*, which was the *balance in hand* at the end of August 31st, *brought forward*. But the exception is more apparent than real. £90 was drawn from the bank during the month of September, and the balance of 10*s.*, making the total of the Received column £90 10*s.*, was itself the unexpended portion of money drawn from the bank at an earlier date. It is, indeed, a very important point to remember that nowadays, in nearly all well-conducted business houses, the whole of the money received from customers and other outside sources is lodged in the bank daily without any deductions. Consequently, if there is no money in the till with which to meet expenses that have to be paid out of Petty Cash, the only way to get it is by drawing a cheque and cashing it at the bank. We shall see later how Messrs. Bevan & Kirk's banking account is affected by the withdrawal of £90 in the month of September, but we must now deal with the Paid column in the Petty Cash Book.

Petty Cash Payments. We observe that during the month a total amount of £89 13*s.* 11*d.* was expended, leaving a balance of 16*s.* 1*d.* to be carried into the Received column on October 2nd—October 1st falling on Sunday. For the purpose of analysing this expenditure under various heads—thereby reducing the labour of posting to the ledger—the right-hand side of the Petty Cash Book is ruled with several money columns and one folio column. Each payment, besides being entered in the Paid column, finds a place in one or other of the analysis columns, and it therefore follows that the cross-casting of the totals of these columns should equal the total amount expended: 7*s.* 2*d.* + 10*s.* 2*d.* + 3*s.* 4*d.* + £3 11*s.* 11*d.* + £2 0*s.* 0*d.* + £83 1*s.* 4*d.* = £89 13*s.* 11*d.* Having proved in this way the correctness of our analysis, the next step is to make use of the information it affords us. This we shall proceed to do in the next article.

The Clerk in Shakespeare's Days. Knowing what is to-day expected even from the office-boy in the way of accomplishments, it is amusing to learn from Shakespearean drama what the populace thought of clerical skill in the days of the Tudors. The passage is taken from the second part of "King Henry VI.," in which play the rebellion of Jack Cade occupies a leading part:

SCENE II. BLACKHEATH.

[*Enter some, bringing in the Clerk of Chatham.*]

Smith. The Clerk of Chatham: he can write and read, and cast account.
Cade. O monstrous!
Smith. We took him setting of boys copies.
Cade. Here's a villain!
Smith. 'Has a book in his pocket with red letters in 't.
Cade. Nay, then, he is a conjurer.
Dick. Nay, he can make obligations and write court-hand.
Cade. I am sorry for 't: the man is a proper man, of mine honour; unless I find him guilty, he shall not die.—Come hither, sirrah. I must examine thee: what is thy name?
Clerk. Emmanuel.
Cade. Dost thou use to write thy name? or hast thou a mark to thyself, like an honest, plain-dealing man?
Clerk. Sir, I thank God, I have been so well brought up that I can write my name.
All. He hath confessed: away with him! he's a villain, and a traitor.
Cade. Away with him, I say! Hang him with his pen and ink-horn about his neck.

[*Exeunt some with the Clerk.*]

Now that our junior clerk is fairly launched on his career, it will be well for him to pause for a time to consider the various technical terms with which he ought to be familiar. The short dictionary of these which follows deals only with the common terms in general use. It is not possible, of course, in so short a space, to include those which are peculiar to any one branch of the profession.

The List of Abbreviations, and the Table of Coinages, Weights and Measures for the chief countries of the world, will be found equally helpful.

NOTE. The figure 2*s.* 2*d.* near the bottom of the last column in the table on page 149 should be 2*s.* 6*d.*

To be continued

A SHORT DICTIONARY OF COMMERCIAL TERMS

Compiled by C. S. Kent.

Abbreviations in brackets are explained in the Dictionary of Abbreviations appended.

ABANDONMENT, Notice of—In marine insurance, a notice to underwriters, prior to making claim for total loss, that the insured property is *abandoned* to them.

Abstract—A summary or abridgment.

Accommodation bill—Bill of exchange, not founded upon a prior debt, but accepted for the *accommodation* of one or more parties to the bill.

Account [a/c]—Collection of items under one ledger heading. Also a statement showing cost of goods bought or sold, or the amount owed by one person to another.

Accountant—A person skilled in keeping accounts.

Account Current [A/C]—A statement in the form of Dr. and Cr., giving details of a series of mercantile transactions, in order of dates, between certain parties.

Account Sales [A/S]—Account showing particulars of *sales* effected and expenses incurred by an agent on behalf of his principal.

Actuary—A person specially qualified to make computations relating to life insurance and similar schemes.

Adjustment—Settlement of a claim, in particular of an insurance claim. In bookkeeping, the rectification of differences between two accounts or sets of figures which ought to agree.

Ad valorem duty—Duty levied on merchandise in proportion to its value and not according to quantity.

Advance—Money on account of payment for sales or services.

Adventure—Trading enterprise of a speculative nature.

Advice—Notification regarding mercantile transactions, especially despatch of goods.

Affidavit—Sworn written declaration.

Agenda—Memoranda of *things to be done*.

Agio—Difference in value between various kinds of money of the same country and denomination. Also difference between real and nominal value of money.

Allotment—Distribution of shares of an incorporated company.

Annuity—Fixed amount payable each year either in one sum or by instalments.

Annuity-certain—An annuity beginning immediately, payable over a definite term of years.

Annuity-contingent—An annuity payable only when prescribed conditions are fulfilled; *e.g.* a life annuity ceases with the death of the annuitant.

Annuity-deferred—A deferred annuity is one which begins after the expiration of a certain period.

Arbitration—The settling of disputes by decision of neutral persons (*arbitrators*) chosen by mutual arrangement.

Arbitration of Exchange—Comparison of direct rate of exchange for remittance between two countries with that obtained by remitting through intermediate places to see which is more advantageous. When sent through one intermediate place only it is called *simple* arbitration, when through more than one, *compound*.

Articles of Association—A deed containing the internal regulations of an incorporated company, by which the management of the business is governed.

Assets—The term given to the entire possessions of value of a person or company, whether cash, properties, or privileges.

Assignee—The person to whom an assignment is made.

Assignment—Transfer of title or interest in any property. This name is given both to the action and to the document making such transfer.

Attachment, Notice of—Instruction to third parties, called *garnishees*, that property held by them, belonging to a person on whom some claim is made, must not be disposed of pending settlement of claim.

Attorney—One empowered by means of a document (called the *power of attorney*) to act and sign on behalf of another.

Audit—Examination by qualified persons, called *auditors*, of books and accounts to prevent or discover fraud on the part of the person keeping them.

Average [Av.]—A term in marine insurance for dividing the loss to insurers on any damage or extraordinary expenditure in respect of ships and goods. When incurred for the common safety or benefit it is termed *general average*, otherwise it is *particular average*.

Average Stater—Person employed by the insured to prepare statements of marine insurance claims, which sometimes are very intricate.

Award—The recorded decision in an arbitration.

BACKWARDATION—Stock Exchange charge for postponing the settlement of a "bear" account.

Balance of Trade—Difference between total value of a country's imports and exports in a year.

Balance-sheet—Abstract shewing liabilities and assets of an undertaking.

Bank—An establishment where money is received for custody or deposit, and repaid on demand or according to arrangement, or remitted according to instructions.

Bank Bill—Promissory note or bill of exchange issued or accepted by a bank.

Bank Charter—Charter of incorporation of the Bank of England. First issued in 1694, but renewed in modified forms at various intervals. Confers privileges on the Bank of England which are not enjoyed by other banks.

Bank Notes—Promissory notes on bank of issue, promising to pay their face value to bearer on demand.

Bank Post Bill [B.P.B.]—Bank of England bills of Exchange for postal payments payable to order at 7 or 60 days' sight.

Bank Rate—Percentage charged by Bank of England for discounting bills of exchange.

Bank Returns—Weekly statements shewing financial positions of national banks. Issued for information of public.

Bankrupt—When a person is insolvent, *i.e.* unable to pay his debts in full and is compelled to place his affairs in the hands of his creditors, upon application by himself or his creditors he will be adjudged a bankrupt by the court.

Barratry—Fraud or criminal conduct of master or mariners of a vessel whereby either the owners or insurers of ship or cargo are exposed to loss.

Barter—Exchange of goods for goods without the aid of money.

Bear—Speculator who sells for future delivery stocks or shares he does not at present possess, hoping to buy them in meantime at a lower rate.

Bill Book [B.B.]—Book in which a record of Bills Payable and Receivable is kept.

Bill of Entry—Statement to Customs officials in prescribed form giving particulars of goods imported or shipped.

Bill of Exchange [B/E]—Order signed by one person (the *drawer*) for payment to be made by another (the *drawee*) to the drawer, or anyone appointed by him.

Bill of Lading [B/L]—Document acknowledging receipt of goods on board ship for carriage on agreed conditions.

Bill Payable [B/P]—Bill of Exchange or Promissory Note, amount of which is payable by giver at a future date named therein.

Bill Receivable [B/R]—Bill of Exchange or Promissory Note, value of which is receivable by holder at a future date, named therein.

Bill of Sale [B/S]—A Contract making absolute or conditional transfer of title to goods as security for debt.

Bill of Sight—Provisional form of Customs declaration by importer given when he is ignorant of exact nature or quantity of goods to be landed. He is thus enabled to subsequently make a correct Bill of Entry.

Boarding Stations—Places appointed where ships *bring to* so that Customs' officers may board them for examination.

Bond—A document by which a person agrees to pay a certain sum at a stated time, or under certain circumstances.

Bonded Warehouse—Secure place sanctioned by Board of Customs for deposit of dutiable goods, without payment of duty until they are *cleared*, *i.e.* removed. Goods thus stored are called *Bonded Goods*.

Bonus—An extra dividend given to shareholders in a public company, when especially good profits are made. Also term given to a periodical addition made to policies of Life Insurance out of Company's profits.

Book Debts—Amount due to a trader from his debtors as shown by his books. Generally divided into three classes—"good," "doubtful," "bad."

Bottomry Bond—The mortgage of a ship by captain or owners to obtain money needed for special purposes, such as effecting repairs.

Bought and Sold Notes—Contracts which brokers and others send to each other on conclusion of the arrangements for sales or purchases. Also known as "Contract Notes."

Bourse—Continental Stock Exchanges or Money Markets.

Brokerage—Remuneration to brokers for their services.

Brokers—Middlemen between buyers and sellers of commodities. There are various classes, the following being examples:

- Bill Brokers—persons who deal in Bills of Exchange.
- Insurance Brokers—persons who effect insurance, acting for insurers and insured.
- Ship Brokers—persons who procure cargoes for ships.
- Stock Brokers—persons who buy and sell Stock Exchange securities for the public.

Bucket Shop—Office of outside stockbroker or one who does not belong to a recognised Stock Exchange. They are often fraudulent concerns.

Bull—Speculator who buys stocks or shares, hoping to sell in the meanwhile at a high rate before time of settlement arrives.

Bullion—Gold and silver not coined into money, but in bars and other forms. Sometimes the term is used to include gold and silver in coined state.

CALL—A demand for money in payment of instalment due on shares in public companies.

Cancel—To write across a Bill, Bond, etc., the word *cancelled*, thus making it of no effect.

Capital—The amount invested in a business or public company.

Cargo—Merchandise carried on board ship.

Cash—The term given generally to coin or banknotes; sometimes includes drafts, bonds, and other readily negotiable instruments.

Cash Account—An account in which only entries relating to cash transactions are made.

Chamber of Commerce—A local association of men interested in commerce; formed for the regulation and protection of trade interests.

Charter—A crown grant which confers privileges on recipients upon the fulfilment of certain specified conditions.

Charter Party [C/P]—An agreement whereby a ship or part thereof is hired for a certain time, voyage, or number of voyages.

Cheque—A written order to a banker to pay the person named therein, or one duly authorised to represent him, a stated sum. If crossed & Co. or payment can only be obtained through another bank.

Circular Note [C N]—Letter of credit issued on foreign firms by bankers to travellers, so that the latter do not have to carry inconveniently large sums of money.

Circulating Medium—The authorised or recognised means of making payments.

Clearing—This term is used in different branches of trade to denote different actions. For instance, to Clear a Vessel is to furnish particulars of a ship and its cargo at the Custom House when it is about to leave port. Clearing in Banking is a plan adopted by Bankers for exchanging cheques and bills daily instead of presenting each one separately at the Bank or business house upon which they are drawn. Railway Clearing is carried on by the association regulated by Act of Parliament, by which English and Scotch Railway Companies are apportioned out the amounts due to them in consideration of traffic which passes over the lines of more than one company.

Collateral Security—An indirect or secondary security generally for the fulfilment of a contract or for money lent.

Commission—An allowance according to value made to agents for transacting business for others.

Company—Association of persons for developing or carrying on any business or businesses.

Composition—Part payment by a bankrupt or insolvent in settlement of debts owing by him.

Compound Interest—Interest paid not only on money lent, but also on the interest which accrues thereon from time to time, and which is added to the original amount, instead of being paid to the lender when due.

Concession—A grant of privileges by a Government to persons carrying out undertakings which will be beneficial to the interests of the country.

Consignment—Goods sent to a person (called the Consignee) by another (called the Consignor) for sale or for delivery according to given directions.

Consul—An officer appointed by the Government of a state to protect its commercial interests in a foreign country.

Contango—The additional rate of interest charged for carrying over a "bull" transaction till the next settlement day.

Contingencies—Liabilities which may probably arise, but which cannot be provided for with exactitude.

Continuation—Carrying over transactions from one settling day to another.

Contraband—Goods imported or exported contrary to the law of the country.

Contract—A binding agreement.

Coupon—A note or warrant for interest or dividend attached to transferable bonds for the purpose of being detached and presented for payment when such interest or dividend falls due.

Credit [Cr.]—Term used when goods are supplied with the understanding that payment shall be made at a future date. The person who thus sells his goods is called the Creditor and the buyer the Debtor.

Currency—The lawful coinage or means of making payment in a country.

Customs Duties—Taxes levied upon the importation or exportation of commodities; generally imposed as a means of revenue to a country.

DAYS OF GRACE—The number of days which expire after the day stated on a bill of exchange as that on which payment is due before such payment can be legally demanded. The number varies in different parts of the world, but in the United Kingdom and the United States three days are allowed on all bills of exchange except on those payable on demand or at sight.

Debenture—Deeds given by public companies as mortgages on their property for money borrowed. Should the lender not be repaid at the specified time, or in the event of default, he has a right to foreclose, *i.e.* to seize the property on which the mortgage is raised.

Debit—To make an entry on the Dr. side of an account.

Del Credere—An engagement entered into by an agent, for which he receives an extra commission, by which he guarantees that all goods which he may sell for his principal shall be paid for. This extra commission is called a Del Credere Commission.

Demurrage—A charge per day made by the owner of a vessel as compensation for its detention beyond a specified time.

Dependencies—The term given to assets which may probably accrue, but whose amount one cannot determine correctly in advance.

Deposit—The name given to a sum of money when placed with bankers at an agreed rate of interest for a stipulated time, though sometimes placed for an unlimited time. Also the part payment of goods at time of ordering and before delivery as evidence of *bona-fides*.

Depositor—One who makes a deposit.

Derelict—Vessel found at sea without anyone in charge.

Deviation—Marine insurance term for departure from terms of policy. If such departure is avoidable, it releases the underwriters from risk.

Directors—Persons who carry on the management of a business for its proprietors.

Discount—Allowance for payment when made before due.

Dishonour a Bill, To—When the drawee refuses to accept a Bill, or an acceptor fails to pay it when due, the Bill is said to be dishonoured.

Dividend—(*a*) Payment of share of profits due on money invested; also interest on National Debt. (*b*) Money paid by bankrupts to creditors reckoned at so much "in the £." That is to say, for each 20*s*. of debt he pays a sum in the proportion of his assets to his debts.

Dock—An artificial basin in which ships are received for loading and unloading cargo, or for the purpose of being repaired. The tolls charged for use of docks are called Dock Dues.

Dock Warrant—Warrant for goods in charge of dock companies giving full particulars of such goods.

Dock Weight Notes—Documents issued by dock companies giving specifications similar to dock warrants of imported goods, but given upon payment of deposit, whereas warrants are only issued after full payment.

Draft—A term used in several ways. Usually denotes a cheque or bill of exchange.

Drawback—Duty paid on imported goods, but repaid owing to re-exportation. When goods upon which excise has been paid are exported, the amount thus paid is returned and is also called drawback.

Drawer—For this term, and for Drawee, see *Bill of Exchange*.

Dunnage—Anything used to protect ship's cargo from damage during voyage.

Duties—Tax, toll, or impost upon merchandise.

EMBARGO—Order which prevents a ship's sailing or removal of goods.

Endorse—When a person (called the endorser) signs his name on the back of a draft, etc., he endorses it.

Entrepôt—Intermediate port or warehouse for the temporary reception of merchandise in course of transit.

Exchange—To give or take one thing for another.

Exchequer Bills—Promissory notes issued by Parliamentary authority.

Excise—Also called Inland Revenue. A tax or duty upon certain articles of home production and consumption.

Executor—Person appointed by a testator to see that the instructions in his (the testator's) will are duly carried out. A woman is an Executrix.

Ex-Dividend [x d]—Without the accrued or accruing dividend.

Ex-Interest [x in]—Without the accrued or accruing interest.

Exportation—Sending goods out of the country.

FAILURE—Suspension of payment by a debtor when he cannot meet demands.

Fathom—Six feet. Commonly used by sailors.

Fiduciary Loan—Loan granted to a person without security by a lender who trusts to the borrower's honour.

Firm—Business carried on by more than one person, or in the name of more than one person.

Flotsam—Goods found floating after shipwreck.

Force Majeure—Circumstances over which human beings have no control.

Foreclose, to—See *Debentures*.

Free Port—Port where no import or export duties are levied.

Freight—Charge made for carriage of goods by water. Also a ship's cargo.

Funds—Stock; capital; interest—carrying Government debts and Government stock.

GARBLE—Dross or refuse picked from spices, tobacco, etc., in sorting.

Garnishee—See *Attachment, Notice of*, for this term, and also for *Garnishment*.

Gazette, the London—The official publication of the Government.

Goodwill—The value of an established business connection.

Gross—Weight or amount without deduction whatsoever. A gross of articles means 144 articles.

Guarantee — Undertaking to fulfil another person's engagements should he be unable to do so.

HONOUR, To—To meet a claim or obligation at the proper time.

Hypothecation—The giving of a lien upon property or the pledging of documents conveying right thereto whilst retaining possession of property.

IMPORTATION — Bringing of goods into a country.

Impost—Tax or duty, generally on imports.

Indenture—Written agreement with special provisions.

Insolvent—Person whose assets are less than his liabilities.

Insurance—Contract between two parties, whereby one (the insurer) agrees to indemnify the other (the insured) against loss in the event of certain specified occurrences, in consideration of the payment of an agreed sum.

Interest—Profit derived from the employment of capital, either invested or on loan.

Interim Dividend—Provisional distribution of profits either before proper dividend or before net profits are known.

In transitu—In course of transit.

Invest—To lay out money with the idea of making profit.

Invoice—Account sent by a seller of goods to the buyer giving particulars of quantity and price.

JERQUER—A Customs official, who examines ship's cargo to prevent goods being imported without paying duty.

Jetsam—Term used in marine insurance when a ship's cargo or part thereof is cast into the sea and sinks.

Jettison—The sacrificing of a part of a ship's cargo or rigging to preserve the remainder.

LANDING ACCOUNTS—Dock companies' accounts of all goods landed, with full particulars as to weight, condition, etc.

Landing Waiter—Customs official who examines goods liable to duty after landing.

Lay Days—Days allowed for loading or unloading ships as agreed upon between owners and charterers.

Lazaretto—Building or ship in a seaport where goods from ships in quarantine are fumigated.

Lease—Conveyance letting premises or land for a certain number of years. The person who grants this is the Lessor; the person to whom it is granted is called the Lessee or Leaseholder.

Letter of Credit—Letter given by bankers or merchants authorising their agents to pay money to the bearer.

Letter of Licence—Document signed by creditors of person insolvent or in difficulties, allowing his business to be carried on for a specified time without payment of their claims.

Letter of Marque—Government licence issued in time of war authorising merchants to fit out privateers to prey upon the enemy.

Lien—Right of claim upon goods, etc., generally granted as security for debt.

Lighterage—Charge for carriage of goods by water in barges or lighters.

Limitation — Statutory period after which debts cannot be recovered, usually six years, but sometimes twenty.

Limited Liability Company—Public company in which shareholders cannot be called upon to pay more than the nominal value of the shares held.

Liquidation—The winding up of a business.

Lloyd's—The rooms at the Royal Exchange where underwriters attend to transact business. Formerly they met at Lloyd's Coffee House, whence the name.

Lloyd's Bonds—When a company has issued the full legal amount of debentures and wishes to incur liability, promissory notes are given as security, and these are called Lloyd's Bonds after the name of their originator.

Locum Tenens — Temporary substitute.

Log Book—Book kept by captain of a ship for recording particulars of voyages.

MANIFEST—Statement from owners of ship giving full details of cargo and voyage sent to their agents. It is made out previous to the ship's sailing, and a copy given to Customs authorities.

Master—Navigator of a merchant ship.

Maturity—Date when drafts, etc., become due.

Measurement Goods—Name given to goods which take up more than the average room in proportion to their weight, because freight is therefore charged upon the space. Forty cubic feet are reckoned as a ton.

Memorandum of Association — Stamped document setting forth the objects, capital, etc., of a limited liability company.

Merchandise—Goods generally.

Merchant—A trader, especially one importing or exporting.

Metric System—System of weights and measures founded on Decimals. See *Mathematics*, for full exposition.

Middleman—An intermediary, such as an agent, broker, etc.

Minute-book—Book in which are entered the records or *minutes* of the meetings of a public company or society.

Monopoly—Exclusive right to carry on a certain business in a country. Government trading monopolies have long been illegal in Great Britain.

Mortgage—Pledging of property as security for debt. Should the interest not be paid, the lender may seize the property.

Muster—A sample.

NEGOTIABLE DOCUMENT—One which, when transferred, carries with it the legal right to the property specified therein.

Nett, or Net—What remains after the total deductions, if any, have been made.

Notary Public [N.P.]—Official authorised to attest or copy written documents. He also presents for the second time dishonoured or non-accepted bills, protesting against and noting the dishonouring.

OPEN POLICY—When the value of a cargo cannot be exactly fixed, insurance is effected for an estimated sum and adjusted afterwards.

PAR—The original amount paid for a share.

Pass Book—Book given by a banker to customer and showing receipts and payments on the latter's account.

Patent—Privilege granted to an inventor, giving sole right to manufacture his invention for a term of years. Its holder is called the Patentee.

Per cent. [p.c. or %]—Proportion per hundred.

Permit—Revenue officer's permission to remove articles on which duty has been paid.

Pilot—Qualified person authorised to navigate ships in dangerous places.

Plant—Machinery, tools, etc., used to carry on a business.

Policy—Document setting forth insurance contract terms.

Post-date, To—To date a document forward.

Précis—An abridgment setting forth the most important contents of a document or documents in the form of a narrative.

Premium—(*a*) Periodical payment for insurance. (*b*) When stock is quoted above par the excess is premium.

Present a Bill, To—A bill is presented for acceptance or payment.

Price Current [P.C.]—List issued by a merchant or manufacturer to customers showing current market prices of goods.

Prime Cost—Original cost of an article before any charge is added.

Procuration — Authority to act for another.

Produce—Native productions.

Pro Formâ—Before engaging in an adventure a merchant usually has what is called a "pro formâ" account sales drawn up from past similar transactions to find out probable result of the deal. Pro formâ invoice is one sent for payment before dispatch of the goods, or in order that a prospective buyer may find out the cost of certain goods.

Promissory Note—Written promise to pay a sum at a specified time.

Prompt—The date on which payment should be made for goods sold on credit as agreed.

Proof in Bankruptcy—Creditor's affidavit that his claim on a bankrupt's estate is correct.

Pro rata—In proportion.

Proxy—The name given to a person who acts for another, and also to the document which authorises him to act.

QUARANTINE—Prohibition of communication between the shore and ships from which there is fear of infection from contagious disease.

Quotation—Prices at which a merchant offers goods.

RAILWAY CLEARING HOUSE — See *Clearing*.

Rate of Exchange—The amount given in one country's currency for a sum in another currency. Rates of exchange fluctuate under various influences.

Real Estate—Immovable property.

Rebate—Allowance given by bankers in consideration for taking up a bill of exchange before it has matured.

Receipt—Written acknowledgment that something has been received.

Reference—Declaration as to a person's commercial integrity.

Remittance—Sum of money sent.

Reserve—Funds kept apart to meet special contingency.

Revenue—Income, usually of a country.

Reversion—The right to property on the occurrence of a certain event, such as, *e.g.* the death of a person.

SALVAGE — Goods rescued, or the money paid for their rescue from damage or loss at sea, or fire on land.

Sample—Small quantity of goods given as a specimen.

Scrip—Receipt for money paid as instalments for shares in public companies.

Securities—Documents giving to the holder the right to possess certain property.

Set-off—When one person makes a claim on another and the latter makes a counter-claim on the same matter the latter claim is a set-off.

Settlement—Payment of an account.

Shares—The units of ownership in a public company, generally £1, £10, or £100.

Simple Interest—Interest on money, paid when due to the lender.
Sinking Fund—A fund built up for a special purpose, usually the redemption of capital.
Sleeping Partners — Business associates who take no active management.
Solvent—Able to pay liabilities in full.
Specie—Coined money.
Staple—The main production of a country or a town.
Sterling—The name by which English money is distinguished.
Stevedore—Expert employed to superintend the stowing away of a cargo, to prevent damage.
Stock—(*a*) Accumulation of goods or money. (*b*) The share capital of a public company.
Stock Exchange—The building in which stockbrokers carry on business.
Stop a Cheque, To—To give instructions to one's bankers not to pay a certain cheque.
Supercargo—A person on board ship in charge of cargo.
Suspension of Payment — Discontinuance of paying debts upon discovery of insolvency.

TARE—Allowance made for the weight of the package containing goods.
Tariff—Table of charges.
Tender—Offer for the supply of goods upon stipulated conditions.
Tret—An allowance of 4 in every 104 on certain goods for waste, etc.
Trinity House — The establishment which superintends British shipping interests by erecting and controlling lighthouses, etc.
Truck System—Part or total payment of workmen in goods instead of money.
Trustee—Person authorised to manage the property of another.

ULLAGE—Quantity wanting to fill a cask. Sometimes applied to the quantity of liquor in a cask.
Underwriter (U/w) — A marine insurer; so called from his signature under each policy.
Usance—Period allowed between two places for the currency of foreign bills of exchange.

VENDOR—A seller.
Voucher — Written document giving proof of money transaction.

WHARFAGE—Charge made for the receipt and removal of cargo either in loading or unloading.
Winding-up—Settling affairs preparatory to the termination of a business.

A SHORT DICTIONARY OF COMMERCIAL ABBREVIATIONS

@—To, at, or from
A/C—Account Current.
A/c—Account.
A/d—After date.
Adv.—Advice.
Advt.—Advertisement.
Agst.—Against.
Agt.—Agent.
A1—First-class at Lloyd's.
A/S—Account Sales.
Assn.—Association.
A/V—Ad valorem, according to value.
Av—Average.

Back.—Backwardation
Bal.—Balance.
B.B.—Bill Book.
b/d—Brought down
B/E—Bill of Exchange.
B/F—Brought forward
B/L—Bill of Lading.
B.N.—Bank Note.
b/o—Brought over.
B/P—Bill Payable.
B.P.B.—Bank Post Bill.
B/R—Bill Receivable.
B/S—Bill of Sale.

C/A—Capital Account.
C.B.—Cash Book.
c/d—Carried down.
C/F—Carried forward.
Cgo.—Contango.
C.H.—Custom House.
'Change—Exchange.
Chq.—Cheque.
C.I.F.—Cost, insurance and freight.
C/N—Credit or circular note.
Co.—Company, County.
c/o—Carried over (Book-keeping).
c/o—Care of.
C.O.D.—Cash on Delivery.
Com.—Commission.
C.P.—Carriage paid.
C/P—Charter Party.
Cr.—Credit, Creditor.
Curt.—Current; of the present month.
Cwt.—Hundredweight.

d.—Pence.
D.B.—Day Book.
Dbk.—Drawback.
D/d—Days' date.
Deb.—Debenture.
Dis.—Discount.
D/N—Debit Note.
do. or ditto—The same.
doz.—Dozen.
Dr.—Debitor, Debtor.
Drs.—Debtors.
D/S—Days' sight.
D/W—Dock Warrant.
Dwt.—Pennyweight.

E.E.—Errors Excepted.
E.&O.E.—Errors & Omissions Excepted.
e.g.—For example.
entd.—Entered.
etc.—And so on.
Ex.—Example.

F.a.a.—Free of all average.
F.a.s.—Free alongside.
F.a.q.—Fair average quality.
Fcp.—Foolscap.
F.i.t.—Free of income tax
F.o.b.—Free on board.
Fol.—Folio.
F.p.a.—Free of particular average.
Frt.—Freight.
Fthm.—Fathom.

G/a—General average.
G. B.—Great Britain.
G.P.O.—General Post Office.
gr.—Gross.

I.B.—Invoice Book.
i.e.—That is.
inst.—Of the present month
Int.—Interest.
Inv.—Invoice.
I.O.U.—I owe you.
I.W.—Isle of Wight.

J/A—Joint Account.
Jun. or Jr.—Junior.

£—Pound sterling.
£E—Pounds Egyptian.
£T—Pounds Turkish.
lb. or lbs.—Pound avoirdupois.
L/C—Letter of Credit.
£.s.d.—Pounds, shillings, pence.
Ltd.—Limited.

M/d—Months' date.
Messrs.—Sirs.
Mos.—Months.
M/s—Months' sight.

N.B.—*Nota bene*; Mark well.
N.B.—North Britain, *i.e.* Scotland.
No.—Number.
N.P.—Notary Public.
Nos.—Numbers.

O/a—On account of.
O/c—Overcharge.
O/d—On demand.
O.H.M.S.—On His Majesty's Service.
Ord.—Ordinary.
O/S—Old style.
Oz.—Ounce.

P/A—Power of Attorney.
P.C.—Post-card.
P/C—Price current or petty cash.
p.c.—Per cent.
P.C.B.—Petty Cash Book.
Pd.—Paid.
Per Ann.—By the year.
Per pro.—Per procuration.
P/N—Promissory Note.
P.O.—Post Office or Postal Order.
P.O.O.—Post Office Order.
pp.—Pages.
Pro.—For.
Pro tem.—For the time being.
Prox.—Of next month.
P.S.—Post Scriptum.
Pt.—Pint.
P.T.O.—Please turn over.

Qr.—Quarter.
Qrs.—Quarters.
Qt.—Quart.
q.v.—Which see.
Qy.—Query.

R/D—Refer to drawer.
Re—With regard to.
Recd.—Received.
Rect.—Receipt.
Regd.—Registered.
R.M.S.—Royal Mail Steamer.

\$—Dollars.
s.—Shillings, Steamer.
S.B.—Sales Book.
Scp.—Scrip.
Secy.—Secretary.
Sen.—Senior.
Sgd.—Signed.
Sh.—Share.
S/N—Shipping Note.
S.S. or S/S—Steamship.
Sq. in.—Square inches.
Sq. ft.—Square feet.
Sq. yd.—Square yards.
Sq. m.—Square miles.
st.—Stone.
Stg.—Sterling.
Stk.—Stock.

T.—Tons.
T.O.—Turn over.
T.T.'s—Telegraphic Transfers.

U.K.—United Kingdom.
Ult.—Of last month.
U.S.—United States.
U.S.A.—United States of America.
U/w—Underwriter.

V.—Against.
Via—By way of.
Vide—See.
Viz.—Namely
Vol.—Volume.

Wk.—Week.
Wks.—Weeks.
Wt.—Weight.
W/W—Warehouse Warrant.

x c—Ex coupon.
x d—Ex dividend.
x in—Ex interest.

Yday.—Yesterday.
Yr.—Your.
Yrs.—Yours.

&—And.
&c.—And so on.
#—Numbered (as #1/20).
'—Foot.
"—Inches.
×—By (as 5 × 2, five by two) sign of multiplication.
°—Degree (as 30°, thirty degrees).
%—Per cent. (per hundred).
‰—Per mille (per thousand).
+—Plus; sign of addition.
−—Minus; sign of subtraction.
÷—Sign of division.

COINAGES, WEIGHTS AND MEASURES OF THE WORLD

M after the name of a country denotes that the Metric System is in use. For an explanation of the Metric System—which is likely to be adopted in our own country during the next few years—see MATHEMATICS, page 337. The rates of exchange are, of course, subject to fluctuation, and no fixed relation of coinages can therefore be given.

Country.	Coinage.	Weights.	Measures. Length.	Measures. Capacity.
Argentine Republic (M)	100 Centesimos = 1 Peso (3s. 11½d.) £1 = 5·05 Pesos	Metric	Metric	Metric
Austria-Hungary (M)	(Old) 100 Kreutzen = 1 Florin or Gulden (1s. 11½d.) (New) 100 Heller = 1 Crown (10d.) £1 = 24 Crowns	Metric	Metric	Metric
Belgium (M)	100 Centimes = 1 Franc (9½d) £1 = 25·22 Francs	Metric	Metric	Metric
Brazil (M)	1000 Reis = 1 Milreis (2s. 3d.) £1 = 8·9 Milreis	Metric	Metric	Metric
Chili (Metric System also in use)	100 Centavos = 1 Peso (1s. 6d.) £1 = 13⅓ Pesos	100 Libra = 1 Quintal (101·43 lbs.)	3 Pie = 1 Vara (33·367 ins.)	1 Arroba = 7·749 galls.
China	1000 Cash = 1 Tael (varies, about 2s. 6d.) (The Mexican dollar is generally used by Europeans and Americans and is equivalent to about 2s.)	1 Tael or Liang = 1⅓ oz. 16 Taels = 1 Chin or Chitty 100 Chitty = 1 Tan or Picul	10 Fan = 1 Tsun (1·41 ins.) 10 Tsun = 1 Chih 10 Chih = 1 Chang or 2 Kung 10 Chang = 1 Yin	10 Ho = 1 Sheng (about 20 pints) 10 Sheng = 1 Tou
Denmark	100 Ore = 1 Crown (1s. 1½d.) £1 = 18·2 Crowns	100 Pfund = 1 Centner (100·2 lbs.)	12 Linie = 1 Tomme (1·029 ins.) 12 Tomme = 1 Fod 2 Fod = 1 Alen 3 Alen = 1 Favn 2 Favn = 1 Rode 2000 Rode = 1 Mil	3 Pægle = 1 Pot (1·6991 pints) 2 Pot = 1 Kande 4 Kande = 1 Viertel 4¼ Viertel = 1 Anker 6 Anker = 1 Oxehoved 4 Oxehoved = 1 Fad
Dutch East Indies JAVA	Same as Holland	16 Tael = 1 Catty (1·356 lbs.) 100 Catty = 1 Pecul	12 Duim = 1 Foot (12·36 ins.) 3 Foot = 1 Ell	1 Kan = ·328 gallon
SUMATRA	Same as Holland	16 Tael = 1 Catty (1·356 lbs.) 100 Catty = 1 Pecul	2 Tempo = 1 Junkal (9 ins.) 2 Junkal = 1 Etto 2 Etto = 1 Hailoh 4 Hailoh = 1 Tung	Same as Holland
Egypt	10 Millièmes = 1 Piastre 100 Piastres = 1 Pound (£E1 = 20s. 3½d.) £1 = £E·0985	12 Dirhem = 1 Uckhieh (·0817 lbs.) 12 Uckhieh = 1 Rottolo 100 Rottolo = 1 Cantar 400 Dirhem = 1 Oka	6 Kurat = 1 Rub (6·75 ins.) 4 Rub = 1 Diraâ or Pike 4 Diraâ = 1 Gasab	1 Ardeb (variable) = about 5 bushels in Cairo and 7¼ in Alexandria
France (M)	100 Centimes = 1 Franc (9½d.) £1 = 25·22 Francs	Metric	Metric	Metric
Germany (M)	100 Pfennige = 1 Mark (11¾d.) £1 = 20·40 Marks	Neu Loth = 1 Décagramme Centner = 50 Kilogrammes Tonne = 1000 Kilogrammes	Strich = Millimètre Neu Zoll = Centimètre Kette = Décamètre	Kanne = Litre Schoppen = Half Litre Fass = Hectolitre
Greece (M)	100 Leptá = 1 Drachma (9½d.) £1 = 25·22 Drachmas	Drachme = Gramme Obolos = Décigramme Kokkos = Centigramme	Gramme = Millimètre Daktylos = Centimètre Palame = Decimètre Pecheus = Mètre Stadion = Kilomètre	Kybos = Millilitre Mystron = Centilitre Kotyle = Decilitre Litra = Litre Koilon = Hectolitre

COINAGES, WEIGHTS AND MEASURES OF THE WORLD—continued

Country.	Coinage.	Weights.	Measures. Length.	Measures. Capacity.
Holland (M)	100 Cents = 1 Florin or Gulder (1s. 8d.) £1 = 12 Gulden	Korrel = Decigramme Wigtje = Gramme Lood = Decagramme Onze = Hectogramme Pond = Kilogramme	Streep = Millimètre Duim = Centimètre Palm = Decimètre El = Mètre Roede = Decamètre Mijle = Kilomètre	Vingerhoed = Centilitre Maatje = Decilitre Kan = Litre Vat = Hectolitre
India (M) (Tables vary according to province.)	3 Pie = 1 Pice 4 Pice = 1 Anna 16 Annas = 1 Rupee (1s. 4d.) £1 = 15 Rupees	Metric Ser = Kilogramme	Metric	Metric Ser = Litre
Italy (M)	100 Centesimi = 1 Lira (9½d.) £1 = 25·22 Lira	Metric	Metric	Metric
Japan	100 Sen = 1 Yen (2s. 0½d.) £1 = 9·80 Yen	10 Mo = 1 Rin 10 Rin = 1 Fun 10 Fun = 1 Momme 100 Momme = 1 Kin 1000 Momme = 1 Kwan (8·281 lbs.)	10 Ring = 1 Bu (·1193 in.) 10 Bu = 1 Sun 10 Sun = 1 Shaku 6 Shaku = 1 Ken 10 Shaku = 1 Jo 60 Ken = 1 Cho 36 Cho = 1 Ri	10 Sat = 1 Sai (·00318 pints) 10 Sai = 1 Shaku 10 Shaku = 1 Go 10 Go = 1 Sho 1 Sho = 1 To 10 To = 1 Koku
Malta	British Currency	1 Rotolo = 1·745 lbs.	4 Palmo = 1 Misura (41·103 ins.) 2 Misura = 1 Kanna	1 Pint = ·8331 pint (Eng.)
Norway (M)	100 Ore = 1 Crown (1s. 1¼d.) £1 = 18·20 Crowns	Metric	Metric	Metric
Philippine Islands (Two systems of weights.)	U.S.A. Currency	16 Onzo = 1 Libra (1·0144 lb.) 25 Libra = 1 Arroba 16 Tael = 1 Catty (1·384 lbs.) 100 Catty = 1 Pecul	12 Linea = 1 Pulgada (·927 in.) 12 Pulgada = 1 Pie 3 Pie = 1 Vara	25 Gantah = 1 Caban (21·991 gallons)
Portugal (M)	1000 Reis = 1 Milreis (4s. 5d.) £1 = 4·50 Milreis	Metric	*Metric	Metric
Russia	100 Kopecks = 1 Rouble (2s. 1½d.) £1 = 9·40 Roubles	12 Lani = 1 Funt (·9028 lbs.) 40 Funt = 1 Pood 10 Pood = 1 Berkowitz 3 Berkowitz = 1 Packen	8 Vershok = 1 Stopa (14 ins.) 2 Stopa = 1 Arschine 3 Arschine = 1 Saschen 500 Saschen = 1 Verst	100 Tscharkey = 1 Vedro (2·705 gallons) 3 Vedro = 1 Anker
Spain (M)	100 Centimos = 1 Peseta (7½d.) £1 = 32 Pesetas	Metric	Metric	Metric
Sweden (M)	100 Ore = 1 Crown (1s. 1¼d.) £1 = 18·2 Crowns	Metric	Metric	Metric
Switzerland (M)	100 Centimes = 1 Franc (9½d.) £1 = 25·22 Francs	Metric	Metric	Metric
Turkey	40 Paras = 1 Piastre 100 Piastres = 1 Pound (£T = 18s. 0¾d.) £1 = £T1·107	100 Dirhem = 1 Okiejeh (·7085 lb.) 4 Okiejeh = 1 Oke	3 Berri = 1 Agatsch (3·1150 miles)	11 Rottol = 1 Jubbeh (·4351 bushel) 8 Jubbeh = 1 Fortin
United States of America	100 Cents = 1 Dollar (4s. 1½d.) £1 = 4·86 Dollars	Practically same as English	Practically same as English	Practically same as English

Group 12
MECHANICAL ENGINEERING
3
Continued from page 321

FORCES IN MECHANICAL CONSTRUCTION

Including a Study of the Composition and Resolution of Forces, with their practical application to Crane, Girder and Roof Work

By JOSEPH G. HORNER

Force. Force is that which tends to produce a change in the rate of progress of a moving body, or to bring a body from a state of rest to a state of motion. The actions of pushing, pulling, and lifting are everyday examples of force; so, too, are gravity, friction, the attraction of a magnet, the elasticity of springs, and the expansion of gases, for all these phenomena are able to cause a stationary body to move, or to affect the rate of progress of a body already in motion. The discussion of forces from the point of view of the momentum they produce belongs to dynamics; that branch of mechanics dealing with forces which so act on a body as to compel it to remain at rest is called statics, and it is with these, which balance one another and are in equilibrium, that we are now concerned.

Representation of Forces. To have a complete idea of any force it is necessary to know (*a*) the magnitude of the force; (*b*) its direction; (*c*) its point of application—that is, the point of a body at which the force acts. If we know these three essentials, the abstract idea of such a force may be set down graphically on paper. A dot may stand for the point of application; the line drawn from this dot in any given direction will represent the direction of the force; and as regards the representation of the magnitude of a force, the line will contain as many units of length as there are units of force. Thus, a force of eight pounds might conveniently be represented by a line eight inches in length, or if it were required to show a number of forces in a small diagram, the scale might be a quarter of an inch or half an inch to one pound, or hundredweight, or ton, or whatever unit of force were chosen.

Forces in Equilibrium. If one force only acts on a body, the latter will be set in motion. The least number of forces necessary to preserve a body in equilibrium is evidently two, and the body will remain at rest until one of these is removed or a new one applied. If two or more forces be applied to a body, each of them will evidently tend to move it in a certain direction, but as it is obviously impossible for any substance to move in different directions simultaneously, an intermediate course will be taken. Thus, if two men walk along opposite banks of a river, each trying with equal force to pull a boat towards his bank by means of a rope, the boat will take neither direction but proceed onward in mid-stream. Similarly, a boat does not follow the direction which either oar tends to make it take, but proceeds in a direction between the two. Evidently, then, there exists a single force which would produce exactly the same effect as these two forces acting together. Thus, in **19**, if two forces, *A* and *B*, act at a point, *O*, in a body, their combined effect will be equal to a single force acting somewhere between them. This single force is called the *resultant*, while the two forces to which it is equal are called *components*. Now, if a fresh force, *C*, be applied to *O* exactly equal to this resultant in amount but opposite in direction, the three forces *ABC* will be so balanced that their effect will be neutralised and the particle *O* will remain stationary. The forces are then said to be in equilibrium. This new force, *C*, equal but opposite to the resultant, is called the *equilibrant* and sometimes the *anti-resultant*. The process of finding the resultant of two forces is called the *composition of forces*; but if it be required to replace a single force by two or more forces equivalent in effect, the process is called the *resolution of forces*. Hence two or more forces may be "compounded" into one resultant, or one force may be "resolved" into components.

Parallelogram of Forces. The resultant of two forces acting at a point is found by the application of the famous proposition, the *Parallelogram of Forces*. "If two forces acting on a particle be represented both in direction and in magnitude by adjacent sides of a parallelogram, the direction and magnitude of the resultant of these two forces will be represented by the diagonal of the parallelogram, drawn from the point representing the particle." This will be best understood by a concrete example [20]. Suppose that it is required to find the resultant *R* of two forces, *P* and *Q* acting simultaneously on a particle *O*, *P* being equal to a force of 14 pounds and *Q* 10 pounds, the angle between the two being 60 degrees. If we adopt a scale of a quarter of an inch to one pound, *P* will be represented by a line three and a half inches long, and *Q* by a line two and a half inches in length, and the lines will be drawn at an angle of 60 degrees. Complete the parallelogram and draw the diagonal *R*. Then the line *R* represents the resultant in magnitude and direction of the two forces *P* and *Q*. In length this diagonal would measure approximately five and a quarter inches, which, according to the scale adopted represents a force of 21 pounds. Therefore the 14 pound force *P* and the 10 pound force *Q* acting at an angle of 60 degrees on the particle *O*, would produce exactly the same effect as the single force *R* of 21 pounds. And if another force equal in magnitude but opposite in direction to *R* were applied in the direction *OA*, the forces along *P*, *Q*, and *OA* would be in equilibrium and the particle would remain at rest.

By a similar method the resultant of any number of forces acting at the same point may be graphically found [21]. Let four forces acting at the point O be represented in magnitude and direction by the lines OA, OB, OC, OD. Complete the parallelogram $OAPB$; the diagonal OP is then the resultant of the forces OA and OB. Next complete the parallelogram $OPQC$; the diagonal OQ is then the resultant of the forces OP (which equals OA and OB) and OC. Finally, draw the parallelogram $OQRD$; the diagonal OR is then the resultant of the forces OQ (which equals OA, OB, OC) and OD; OR is therefore the resultant of the four forces OA, OB, OC, OD. Their combined effect both in magnitude and direction is thus represented by the force OR.

Mathematical Solutions. By this graphical method the resultant of any number of forces may be found, and in the greater number of engineering problems this method is generally sufficient, but where mathematical exactness is required, resultants of forces may be determined by trigonometrical or algebraical formulæ. By trigonometry the resultant of two forces inclined to each other at any angle may be found from the formula: $R = \sqrt{P^2 + Q^2 + 2PQ \cos A}$, where R represents the resultant, P and Q the two forces, and A the angle at which these forces act. But where the forces act at certain angles the resultant may be calculated without the aid of trigonometry, an elementary knowledge of algebra being sufficient. These particular cases are given below.

When the angle between two given forces is:

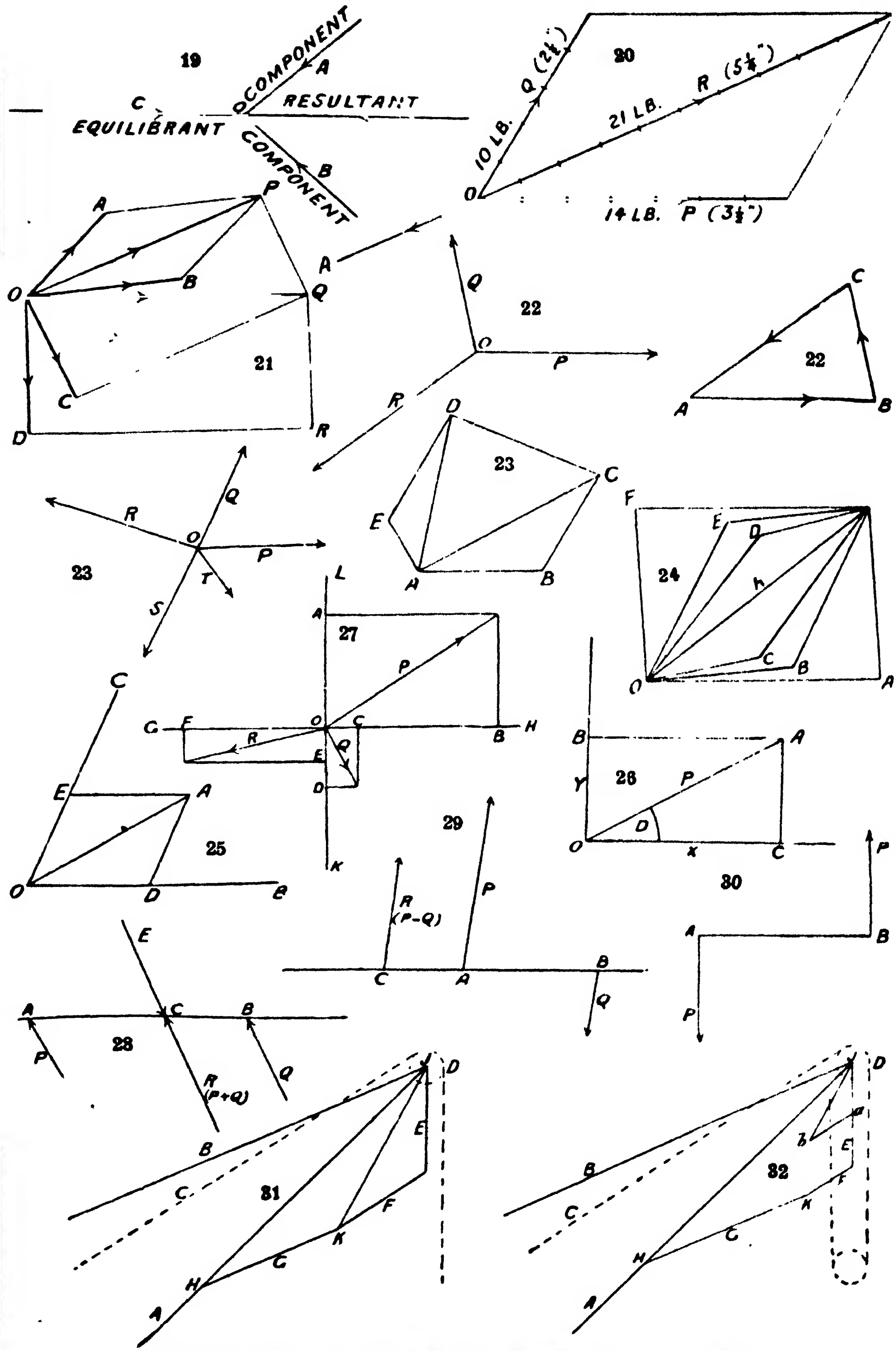
$$
\begin{array}{ll}
30^\circ, & R^2 = P^2 + Q^2 + \sqrt{3}PQ \\
45^\circ, & R^2 = P^2 + Q^2 + \sqrt{2}PQ \\
60^\circ, & R^2 = P^2 + Q^2 + PQ \\
90^\circ, & R^2 = P^2 + Q^2 \\
120^\circ, & R^2 = P^2 + Q^2 - PQ \\
135^\circ, & R^2 = P^2 + Q^2 - \sqrt{2}PQ \\
150^\circ, & R^2 = P^2 + Q^2 - \sqrt{3}PQ
\end{array}
$$

Triangle of Forces. The parallelogram of forces enables us to determine the conditions of equilibrium when *two* forces act at a point. Another highly important proposition, the *Triangle of Forces*, states the conditions under which *three* forces must act that they may balance one another or be in equilibrium. It may be stated thus: "If three forces acting at a point can be represented both in magnitude and direction by the sides of a triangle taken in order, then these three forces will be in equilibrium." Thus in the related diagrams 22, if the three forces P, Q, R, acting at O, are parallel to the sides AB, BC, CA respectively of the triangle ABC, and if also the lengths of these three sides are proportional to the magnitudes of P, Q, R, then shall the forces P, Q, R be in equilibrium. Conversely, if a body remain stationary under the action of three forces acting on a particle, then any triangle which can be drawn with its three sides parallel to the directions of the three forces will have those sides proportional in length to the magnitudes of the forces. It is obviously necessary to take the sides of the triangle "in order," that is, the arrow heads should follow one another in their triangular course as seen in the diagram. If one be reversed, then the triangle would represent two forces and their resultant.

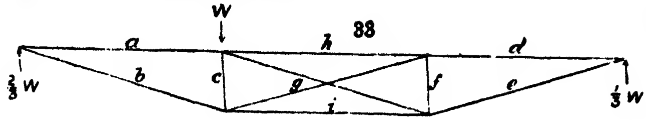
Polygon of Forces. The conditions under which a body remains at rest when a number of forces act in the same plane on one point are stated by the *Polygon of Forces*: "If a number of forces acting at one point can be represented both in magnitude and direction by the sides of a closed polygon taken in order, then these forces will be in equilibrium." In the related diagrams 23 the forces P, Q, R, S, T, acting at O, are represented in magnitude and direction by the sides AB, BC, CD, DE, and EA respectively of the polygon $ABCDE$. Now, AC is the resultant of AB, BC; similarly AD is the resultant of AC and CD; again, AE is the resultant of AD and DE. That is, the resultant of forces P, Q, R, S is represented by AE. But as the force T is represented by EA, which is equal and opposite to AE, the forces are kept in equilibrium.

Resolution of Single Forces. Just as two or more forces may be compounded into a single resultant which would have an exactly similar effect on a particle, so any single force may be resolved into two components producing an equal effect. Obviously, these two components may be in any direction whatever, as an infinite number of parallelograms may be drawn with the same line for their diagonal. For example, in 24 the force R may have for its components any of the pairs of forces represented by the lines OC, OD; OB, OE; OA, OF. It is also evident that any one pair of these forces is equal to any other pair. The greater the angle becomes between any two of the components the greater is their tendency to destroy each other's effect. It is then a simple matter to resolve a force into two components in given directions [25]. Let OA represent the force, and OB, OC the directions along which the components are to act. From the point A draw AD and AE parallel to OC and OB respectively. Then, from the parallelogram of forces it follows that the force OA is equal to, and may be replaced by, the forces OD, OE.

In actual practice it is most often required to resolve a force into components acting along and perpendicular to a given line—*i.e.* at right angles to each other. In 26 let OA represent the given force P. Then OC and OB will represent components acting at right angles, and if these be designated X and Y respectively, the relations between the three forces will be shown by the equation, $P^2 = X^2 + Y^2$. When the angle D is known, either X or Y can be found. The component X is obtained by multiplying P by the cosine of the angle D; Y by multiplying P by the sine of the angle D. In certain cases it is also possible to find X and Y without the aid of trigonometry. Thus, when OA is inclined to OC at an angle of 45 degrees, OCA will be a right-angled isosceles triangle, and it is clear that $OA^2 = 2\,OC^2$; that is, $OC = \frac{OA}{\sqrt{2}}$, or $X = \frac{P}{\sqrt{2}}$, and $Y = \frac{P}{\sqrt{2}}$. Similarly, it can be shown that when the angles at which the force is inclined



ILLUSTRATIONS OF THE COMPOSITION AND RESOLUTION OF FORCES



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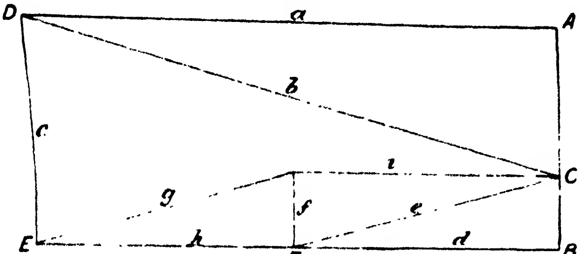

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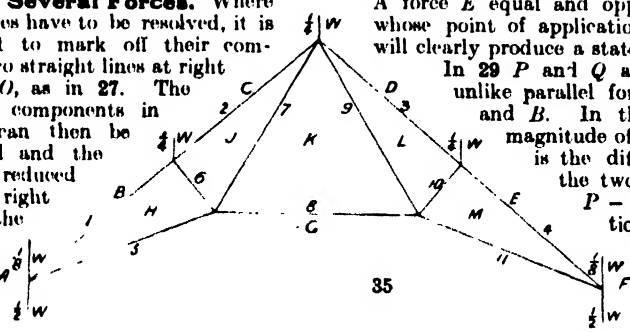
to two perpendicular lines are 30 and 60 degrees respectively, the components will be $\frac{\sqrt{3}P}{2}$ and $\frac{P}{2}$ respectively.

The Case of Several Forces. Where a number of forces have to be resolved, it is most convenient to mark off their components along two straight lines at right angles through O, as in **27**. The sum of all the components in each direction can then be readily obtained and the original forces reduced to two acting at right angles. Let the forces P, Q, R act at O. Through O draw lines GH, KL at right angles, and resolve each force into two components on these lines. Then $P = OA + OB$; $Q = OC + OD$; $R = OF + OE$. Now, along the line GH there are components acting in opposite directions, some to the right $(OC + OB)$, and one to the left (OF). Therefore $OC + OB - OF$ will represent the resultant of the forces acting in this straight line. Similarly, $OA - OE - OD$ gives the algebraical sum of the forces acting in the other direction. If the algebraical sums of the components along these lines be represented by X and Y, and if R denotes the resultant, then $R^2 = X^2 + Y^2$.



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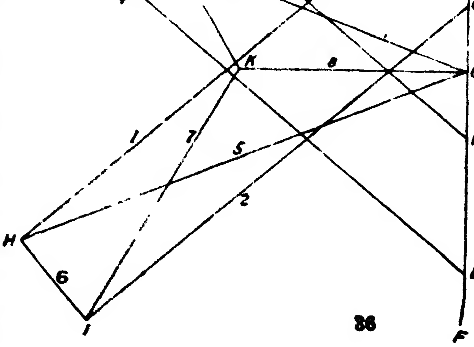
To ensure equilibrium, the sum of the components of the forces along two straight lines at right angles must be separately zero. For if the system of forces is in equilibrium the resultant, R must be zero, that is, $X^2 + Y^2 = O$. But since the squares of all numbers are positive, X and Y must be separately zero, and so $X = O$ and $Y = O$. By calculating the forces which act in two directions at right angles and substituting for X and Y in the above equations, many problems of this class may be solved.

Parallel Forces. When two or more forces act in directions parallel to one another and at different points they are parallel forces—*like*, if they all act in the same direction; *unlike*, if in opposite directions. In **28**, let P, Q be like parallel forces acting on a body at the points A, B. Then (*a*) the magnitude of the resultant equals the sum of the forces, or $R = P + Q$; (*b*) the resultant acts in the same direction—that is, R is parallel to P and Q; (*c*) the point of application of the resultant R divides the line AB into two parts inversely proportional to the forces—*i.e.* AC is proportional to Q, and BC to P, while R is proportional to AB. Hence $P \times AC = Q \times BC$. Or, $\frac{AC}{CB} = \frac{Q}{P}$. This provides a simple means of finding the position of the resultant, for it is only necessary to divide AB into two parts proportional to the numbers representing the parallel forces. If P be twice or three times Q, then CB will be twice or three times AC. The resultant will evidently always be nearer to the greater force. A force E equal and opposite to R, and whose point of application is also at C, will clearly produce a state of equilibrium. In **29** P and Q are unequal and unlike parallel forces acting at A and B. In this case (*a*) the magnitude of the resultant R is the difference between the two forces, or $R = P - Q$; (*b*) the direction of the resultant is the same as that of the greater force P; (*c*) the point of application of the resultant divides the line externally into two parts, which are inversely proportional to the forces.



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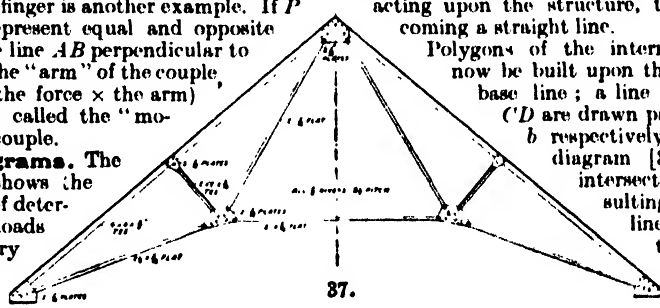
Hence $P \times CA = Q \times CB$. Or, $\frac{CA}{CB} = \frac{Q}{P}$

Referring again to **29**, it is clear that any force R can be resolved into two parallel components P, Q, if BC is to AC as P is to Q.

The resultant of any number of parallel forces in the same direction is found by obtaining the resultant of any two, then the resultant of this resultant and another force, and so on. The final resultant is parallel to the forces and is equal to their sum; but if they act in opposite directions, their resultant equals the difference between the sum of those in one direction and the sum of those acting in the opposite direction.

Couples and Moments. When two parallel forces are equal but unlike (*i.e.* opposite), there can be no resultant, no single force capable of producing the same effect. A body under two such forces cannot be in equilibrium, but will rotate. Two forces such as these form a *couple*. The swinging of the compass needle is a common example, the couple in this case consisting of two equal, parallel, but opposite forces acting north and south respectively. The spinning of a top between the thumb and forefinger is another example. If P and P [**30**] represent equal and opposite forces, then the line AB perpendicular to them is called the "arm" of the couple, and $P \times AB$ (the force $\times$ the arm) equals what is called the "moment" of the couple.

Crane Diagrams. The diagram [**31**] shows the usual method of determining the loads upon an ordinary crane jib and tie. A is the centre line of the jib, B is the centre line of the tie rod, C is the chain line, and D is the jib head pulley.



37.

Draw a line, E, plumb from the centre of the pulley, J, and measure its length by a scale of tons, say, one-eighth of an inch, or quarter of an inch per ton, the total length representing the load on the crane by the method of **20**, but substituting tons for pounds. A line, F, is now drawn to the same scale, and the same length, but parallel to the chain line C. From the point thus obtained, K, a line, G, is drawn parallel to the tie rod, B, until it intersects the jib line, A, at H; the length of the line, G, then represents the load on the tie rods, and the length of the line, H to J, represents the load on the jib. Another line may be drawn from point K to J, and such a line measures the resultant of the chain loads upon the pulley pin at J.

In **32** a similar diagram is shown to illustrate the case of a crane which lifts its load with two falls of chain and snatch block, the return chain being anchored to the jib head as usual. The same procedure is followed, but the line, F, is now only half the length, because although the full load takes effect on line E, yet only half of it is sustained by the chain C.

To obtain the load upon the pulley pin, a separate triangle may be constructed upon the plumb line E by drawing a line, ab, to represent the direction and magnitude of the load on the chain C, the distance, Ja, being, of course, the same; the line, bJ, then gives the resultant upon the pin.

Reciprocal Diagrams. It is, however, not always convenient, nor indeed practicable, to develop a polygon of forces upon the drawing of the framework itself. In such cases it is usual to construct a reciprocal diagram. Fig. **34** gives an example of one applied to the trusses of a traveller beam [**33**] above it. Assuming the load W [**33**] to be directly over one of the struts, the reactions upon the cradles, or end supports, can be determined, and figured thereon. To construct the diagram, mark off to a scale of tons a vertical line, AB [**34**], representing the load, W, acting in a downward direction, and upon the same line mark the reactions or upward forces at the cradles; thus BC represents the reaction on the right-hand cradle of [**33**] = one-third W; while CA represents that on the left-hand cradle = two-thirds W, the two together being equal and opposite to W; the line AB, BCA [**34**] is then a closed polygon of the external forces acting upon the structure, the polygon becoming a straight line.

Polygons of the internal forces may now be built upon this, using it as a base line; a line AD and a line CD are drawn parallel to a and b respectively, in the upper diagram [**33**], until they intersect at D, the resulting lengths of these lines a b represent the loads upon them. A vertical line is now drawn from D to E, representing the load on the member c, which load is W. Starting from the base line again, a line, BF, and a line, CF, are drawn from D to E, representing the load on the member c, which load is W. Starting from the base line again, a line, BF, and a line, CF, are drawn parallel to d and e respectively, until they intersect at F, the resulting lengths representing corresponding loads on those members. From F the lines f, g and h are drawn parallel with their members, and the whole polygon is completed by i.

The above examples are typical of methods adopted in actual practice. In dealing with more complicated framings, particularly those in which the directions of the forces are not very apparent, it is necessary to adopt a system of notation whereby the polygons can be regularly constructed, and the direction of the various forces clearly seen.

Roof Truss. Considering next a simple roof truss as shown in **35**, it is usual to ascertain the loads upon the various members by means of a reciprocal diagram as in the previous example, but the employment of *Bow's notation* is adopted in order to facilitate the construction.

The frame diagram [**35**] is first of all laid down to a convenient scale, and all external loads and

reactions indicated thereon by direction arrows, then the diagram is lettered from left to right with a letter in each space between any two external forces, and also in each of the internal spaces. It is sometimes convenient to figure each separate member of the framework.

The polygon of external forces and reactions is then plotted to a scale of cwts. or tons; in this example, as in the previous one [34], this polygon becomes a straight line.

AB [36] represents the force one-eighth *W* lying between *A* and *B* on the frame diagram. *BC* represents the force one-fourth *W*, which lies between *B* and *C* on the frame diagram, and so in turn are laid down the forces lying between the letters *CD*, *DE*, and *EF*; then the reactions *FG* and *GA*, each equal to one-half *W*, complete the polygon.

The internal load diagram is now drawn, commencing with member 1 lying between *B* and *H* on the frame diagram [35]. This is laid down as line *BH* exactly parallel to member 1 [35], its length being determined by its intersection with line *GH* drawn parallel to member 5; *CJ* and *HJ* may now be drawn parallel to members 2 and 6; then to complete the first half of the diagram, lines *JK* and *KG* are drawn parallel to members 7 and 8. The accuracy of the diagram is tested by its symmetrical completion, and the perfect "closing" of the last line. The nature of the loading, whether compression or tension upon any member, may be determined by the following rule.

Read off the letters on either side of the member in question on the frame diagram in the order in which they occur when turning round either joint, connected with that member in the direction of lettering.

Place an arrow on the corresponding line on the load diagram pointing from the first toward the second letter.

Transfer the arrow back to the frame diagram: if the arrow points toward the joint the member is in compression, if it points away from the joint the member is in tension.

It will be noted in the above example that the external forces are all assumed to be in a vertical plane, whereas in fact a roof has to sustain oblique forces due to wind action. With small roofs it is usual in practice to resolve these oblique forces into vertical loads, and add them to the ordinary dead vertical loads in order to simplify the diagram; when dealing with large roofs, a separate diagram is frequently set out to determine the internal loads due to wind pressure, and the results are added to the ordinary diagram for vertical loads; alternatively a combined diagram can be constructed.

In the above examples the load diagrams are used as a basis for calculating the scantlings of the structure in question. The main body of any member is subjected to either tension or compression, and the material can be proportioned accordingly, whilst the joints must be designed to sustain bending or shearing actions, according to detail of construction.

In the case of the jib and tie [31 and 32], the jib section is calculated as for a column, free at both ends; the tie rods are, of course, in tension, care being taken to see that the ends are forged to be of equal strength to the bar; the head pin may be subjected to a bending moment, or to shearing forces, only according to construction. It is not usual, except in cheap cranes, to attach the tie rods directly to the same pin that carries the head pulley.

With regard to the trussed beam [33], the same remarks apply generally to the tension and compression members; the beam itself, however, has to sustain a bending moment, being at its maximum when the load is in the centre of any bay. In proportioning the tie rods, the screwed ends must be swelled up in order that the area under the thread shall not be less than the area of the rod itself.

When considering framed structures composed of a considerable number of members it is sometimes useful to tabulate them together, with the condition of stress, and an abridged calculation of scantlings. An example of such is given below [37], applicable to a diagram like that in 35, together with a truss detail drawn from same.

TABLE OF MEMBERS AND SCANTLINGS.

Member.	Tension.	Compression.	Scantling.
BH and *EM*	..	68 cwts.	Strut 11 ft. long, 4" × 4" × ½" Tee bar. Factor of safety = 5.
CJ and *DL*	..	58 "	Same section as above for convenience.
HG and *MG*	56 cwts.	..	Area required at 5 tons per □" = ·56 □" 2¼" × $\frac{5}{16}$" flat, − ¾" rivet-hole = ·6 □".
HJ and *LM*	..	12·5 "	Strut 4ft. long, 2" × 2" × $\frac{5}{16}$" Tee bar. Factor of safety = 18.
JK and *LK*	34 "	..	Area required at 5 tons per □" = ·34 □" 2" × $\frac{5}{16}$" flat, − ¾" rivet-hole = ·43 □".
KG . . .	27 "	..	Same section as above for convenience.

It will be observed that some members have a larger factor of safety than others; this arises from manufacturing conditions. There is, for instance, a difference of loading on members *BH* and *CJ*, but it is obviously cheaper and more convenient to run a through member and so theoretically waste material in *CJ*. Again, in *HJ*, *LM*, and *KG* there is a theoretical waste, but these members, if designed with the same factor as the others, would give great trouble in manufacture and in erection, and would certainly give unsatisfactory results on account of their lightness; it is due to this fact that timber trusses are not economical of material.

To be continued

THE STORY OF INDIA AND EGYPT

Hindostan. Buddha and Buddhism. Alexander's Invasion of India. Tamerlane. The Hindu State. Egypt and Its Dynasties

By JUSTIN McCARTHY

Hindostan. India, the great land which has, during most of its history, been described as Hindostan, traces its origin in ages long before ordinary records of national development. In the earliest days of which we can obtain any knowledge, it was inhabited by several aboriginal races who left philological traces and rude monuments. These races were modified by many invasions, Dravidian and others, one of which, an Aryan invasion, gave the early Hindu or Vedic system of religion. The history of India, as we now study it, was made, for the most part, by the Aryan race, a fair-skinned people who settled in many parts of the country, and possessed a certain degree of civilisation.

The crowding together of these different peoples caused much internal disturbance, and led to a vast stream of emigration which flooded other parts of Asia and streamed over into Europe. The story of this prolonged struggle has been preserved in the Vedas, the earliest of the Aryan sacred books, which books have been justly described as holding a place among the most ancient monuments of the human race. Many epic poems were created among those imaginative peoples, and some of them show remarkable affinities to the Greek Iliad, and were, like it, the gradual work of centuries. One of these epic poems, which tells of the conquest by the Aryans of a great part of Hindustan and the Island of Ceylon, may be ranked with the works of Homer and of Virgil.

Buddha. The Hindu, or Vedic, system of religion became corrupted, and it was reformed by Buddhism more than five hundred years before the Christian era. Buddhism is the religion preached by Buddha, a name which signifies the Wise. Buddha's father, the story tells, was born of a royal family, but at an early period of his life Buddha renounced his rank and wealth and went out into the desert to seek for the actual truth and to find inspiration there. After seven years of voluntary exile Buddha returned to his home and his people, and began to preach to crowds of every sort that he could gather around him. He taught what he believed to be the true doctrines, teaching only through the utterance of parables. Buddha's preaching was directed against Brahmanism by insisting on the equality of all men before the moral law, and by substituting virtues which consist in the practice of good deeds for the spurious and fantastic virtues set up by a humanly devised ritual.

The promise of salvation, of union with the divine essence, made to the Brahman alone, was superseded by the recognised capacity of all men, through their merits, to win Nirvana, or deliverance. Buddha broke up priestly heredity by calling to the priesthood the poor and the beggars who devoted themselves to a religious life. He set up for human beings six essentials of perfection to be sought for and obtained by all men: knowledge, which must apply itself to distinguishing between the true and the false; energy, which enables man to strive against man's worst foes, the pleasures of the senses; purity; patience in enduring passing or imagined troubles; charity, the great bond of society; and almsgiving, the necessary result of the doctrine of charity. Buddha announced that he had come to give wisdom to the ignorant, and declared that even the man of noblest intentions and purpose could not accomplish much towards his own salvation unless he made it part of his work to comfort the afflicted, and render help to the miserable. His doctrine he defined as a doctrine of pity. "The prosperous find it difficult, and pride themselves on their birth, but the way of salvation is open to all who annihilate their passions as an elephant overturns a hut made up of reeds."

The Moral Code of Buddha. This simple and pure moral code came as a strange novelty to those who had to endure the dominion of the Brahma system with its law makers, believed to be divinely appointed, its castes, and its eternal aristocracy, set up and maintained by the everlasting rule of the appointed law-givers. We are told that his preaching attracted such masses of converts and became so powerful that, notwithstanding all the efforts which the priestly orders could make to destroy his work, he was enabled to carry on his reforming crusade until he had attained an advanced old age without having to make any appeal to his masses of devoted followers for the use of force in order to sustain him in his mission. Indeed, he preached against the use of force for the establishment of reform, a doctrine very unlike that inculcated by most other innovators, in Asiatic or other countries.

Jainism, which came of the same school of doctrine as Buddhism, had arisen about this time, and remained an existing faith after Buddhism had been banished from India.

Alexander's Invasion of India. A memorable event in the history of India was the invasion of Alexander the Great. Up to the opening of that invasion India had been known to the European world only by name, as a vague sort of region beyond European ken, peopled by races of different colours. Alexander had made many expeditions into Asia already, had conquered many native princes, had traversed Palestine, had helped to free Egypt of Persian domination, had been hailed by the

Egyptians as their deliverer, and had founded the city of Alexandria. Alexander fought his way through a great part of India, and established Greek colonies in many regions. He had, in fact, a gift for colonisation as well as for war, and wherever he made his way he seems to have been able to impress each invaded race with some interest in the language and literature of Greece, and some sense of the importance attaching to Greek institutions. His influence was two-fold, it will be seen, for, while he carried into India ideas brought from Europe's early civilisation, it was through him that the attention of Greece and other European countries first became drawn to the ancient civilisation of India.

Rise of the Mahrattas. The richness and the varied productiveness of the soil in many Indian countries soon became a source of attraction to merchants from all lands civilised enough to spread trade by foreign travel. The Mussulmans of Persia began to invade India, and then there were Turkish invasions and new incursions of the Mongols, one of whose race established at Delhi the dynasty of the Great Mogul which lasted until modern days. The supremacy of the Mogul Empire was overthrown by the rise of the Mahrattas. "Wild Mahratta battle" was destined long later to be a thing of meaning to men of pale face in the days when the Feringhee crossed the Black Water, and laid his hand on Hindu and Mohammedan, Mogul, and Mahratta alike. Thus it will be seen that the native race of India lost its independence at a very early period of its history, but it always retained some of its leading peculiarities in religion, in organisation, and in literature. In the sixth century A.D. Buddhism was suppressed by Brahmanism.

One of the cardinal principles of the Brahmans is that their divinity, Brahma, divided the people from the first into four distinct and separate castes—the priests, the warriors, the merchants, and the artizans. Of these, the first two were established as the ruling castes, and marriage was forbidden between them and the lowest caste. To that lowest order, also, belonged the descendants of the aboriginal population, the conquest of which had opened India to the outer world. Only those who belonged to the caste of the Brahmans, or priests, had the right to expound or even to read the sacred books, and as all the knowledge then within the reach of Indian populations was supposed to be contained in these books, the Brahmans were looked up to as the teachers of everything intellectual, as poets, as physicians, and as expounders of laws. Many struggles took place before the warrior caste could be brought to accept this ascendency and even supremacy being accorded to the priestly teachers.

Tamerlane, Emperor of India. In 1001 A.D. came the Mohammedan conquests under Mahmud of Ghazni, who invaded India through the passes of the Suliman Mountains, and the greater part of India came for a long time under Mohammedan rule. Two hundred years later India was invaded by Genghis Khan, some yet later Mongol invasions were repulsed, but in the fourteenth century Tamerlane, the famous Tartar chief, entering Delhi, declared himself Emperor of India. The history of India had already begun to blend itself with that of the whole outer world, and we shall have occasion to refer to it again and again in this narrative.*

The religious and political organisation which India accepted about nine hundred years before the Christian era is in its principle characteristic of the prevailing system to this day. That principle claims to set forth, as on the authority of revelation from the higher powers, the origin of the world and of the institutions prescribed for the Indian race. The divine authority of the ancient Vedic is still recognised, but all these are declared to be subordinate to Brahma, the absolute ruler of the heavens and the earth.

Keystone of the Hindu State. The whole system bears a certain resemblance in its principal qualities to that scheme of the world's origin and growth which is set forth in the Old Testament. It has been for the most part among the Indian races a system which has undergone no change down to the present day. *The Indian Review* a monthly magazine published in Madras, and issued for publication among English-speaking readers, has in its number for April, 1905, an interesting and instructive article, evidently written by one of the Hindu race. It tells us that "our idea of the sovereign as the parent of his people is the basis of Hindu politics." The writer says that it is "what may, in the language of modern politics, be called the keystone of the constitution of the Hindu state." Then he goes on to say that "the idea of one's own rights is foreign to the Hindu ideal in every department of life." According to this doctrine there is no "self" for the soul or the body of the sovereign or the individual, and the sovereign can seek no salvation for himself individually, but can only obtain it by the faithful discharge of his duty to the highest power and to his subjects and to all around him.

This is, indeed, the central principle of all religious teaching in the modern and the European world, as well as in that of the Hindu races, and is probably not more rigidly carried out by individual beings, whether rulers or subjects, in the one instance than in the other. But it is of much interest for readers to know that the accepted religion of the Hindus takes as its central and guiding principle that doctrine which is the very essence of the Christian faith.

Hinduism and Christianity. It would be needless to say that the existence of so pure and exalted an ideal religious code did not always prevent the Hindu races and the Hindu rulers from quarrelling among themselves, and carrying on fierce wars of conquest and annexation. We have seen throughout our most

* Perhaps this may be a suitable place in which to mention the fact that throughout this History we shall make it our rule to print foreign names according to the recognised fashion of English spelling. In every country it becomes the custom to print foreign names according to the country's own fashion of spelling them, and it would lead only to useless confusion if we were to attempt a correct rendering of the genuine and native nominations given to foreign regions and foreign celebrities.

modern European history that the teachings of Christianity have not always been able to protect peaceful populations from the terrible results brought about by the reckless ambition of Christian rulers. Our object at present is to show that throughout great parts of India's vast territories there have been almost from the birth of recorded time, and still are, populations which are taught and accept the teaching of doctrines proclaiming as their essential principle the existence of a higher power regulating the destinies of humanity, and the truth that man's salvation depends on the discharge of the duties he owes to the higher power and to his fellow-beings, and not merely to his own personal protection, credit, respectability, and worldly advancement.

It is not our intention now to give a minute account of the religious creeds of India; we wish to call the reader's attention to the fact that the principal religious organisations of India have from the earliest periods of which we know anything, and down to the present, borne a greater essential resemblance and affinity to the doctrines of Christianity than to those which were taught and accepted among the Greeks and the Romans, and in later days among the followers of Mahomet. In the study of Indian history we are not helped so much by the existence of ancient monuments as we are in the history of Egypt, Greece, or Rome. There are, indeed, many ancient monuments to be found throughout India, but not many of them bear inscription, device, or symbol which could expound to the student their religious or historical significance.

Egypt. Egypt is, beyond every other country, a land of monuments. All her earlier history is to be traced out through the forms and the inscriptions of her monumental buildings. The great Pyramids themselves, those majestic relics of the far past, those monuments with which the modern tourist from all parts of Europe and the United States is now so familiar, are the tombs of some of Egypt's early kings and are inscribed with the story of their lives and their deeds. There are still to be seen here and there throughout Egypt whole cities which might be described as records of Egyptian history, erected as they were to commemorate the founding or the fall of some dynasty, the establishment or the expulsion of some new invasion. Almost every ancient building in the land is a tomb or a house of prayer, or a tomb and a house of prayer.

Nor are these relics of the historic past to be found only on the surface of the Egyptian soil. Active research throughout Egypt has for centuries past been discovering monuments and houses of prayer below the surface of the earth, and even in the most recent days the patient skill of the explorer into subterranean caverns is still finding new evidences of that worship of divinities and worship of ancestors which belonged to the very heart of the Egyptian race.

From all these memorials it is certain that at the time when the Egyptian populations first came to have any record in actual history they must have already arrived at a very advanced stage of civilisation. The building of the great Pyramids marks an era nearly 4000 years before the birth of Christianity, and the Pyramids themselves, and all the public monuments contemporaneous with them, give the clearest proof that for ages before that period Egypt had been brought to a state of highly advanced civilisation, in the artistic sense at least, entirely unlike that which could possibly have belonged to the doings of merely savage races.

Influence of a Race of Slaves. Egypt was naturally, from the peculiar fertility given to almost the whole of its length and breadth by the frequent overflowings of the sacred river the Nile, a most desired and coveted place of settlement for the inhabitants of neighbouring regions on whom the heat of the African desert burned with unmitigated fierceness. The Egyptian soil was therefore frequently invaded by neighbouring tribes, who endeavoured to settle on the land, and of whom large numbers succeeded in establishing a permanent home there. Then again the Mamelukes, who were originally a race of slaves imported by Egyptian rulers from Turkey and Circassia, became a permanent part of the population and had an important influence on Egyptian history.

The earliest Egyptian race concerning whom we can form any distinct idea appear to have been a red-skinned race, and to have belonged to the population described in Genesis as the tribe of Ham. Those people, who were called Cushites, constituted for many centuries the basis of the population along the shores of the Indian Ocean, the Persian Gulf, and the Red Sea. They divided themselves into several small states, which at last came under the domination of one ruler, and thus established the first royal Egyptian race. This royal dynasty must have been called into existence at least 5000 years before our historical era.

Religious Beliefs. The religious belief which prevailed amongst the early Egyptians was that the country had first been ruled by the gods and then by the demi-gods, who came down to earth in the form of a priestly caste, and that these had at last either voluntarily yielded, or had been compelled to yield, their ruling power and their general influence to a warrior dynasty which was better fitted than a priestly caste to work out to the happiest effect the destinies of Egypt, and to maintain her independence.

For a long time there were two distinct religions prevailing throughout Egypt—the faith professed by the priests and the faith adopted by the people. The religion adopted by the people was the ancient fetichism, and created a number of divinities, many of whom it invested with some of the attributes influencing the life of human beings. The hopes, the passions, the ambitions, all the various cravings of human nature, were represented in this strange form of theology, and it had its divinities also in the form of animal creatures, such as the bull Apis of Memphis, and even many monstrous creations made up of the head of an animal and a human body, or of the head of one animal and the body of another.

The religion of the priests was based upon the principle that there was a struggle between good and evil going on everywhere, the struggle for good represented by Osiris and the struggle for evil represented by Typhon, the god of darkness and destruction. Osiris was typified by the sun, the principle of all life, while nature was typified by Isis, and these two had a divine offspring, Horus. This was a much more exalted form of creed than that generally adopted by the Egyptian people, but as time went on it began to descend more and more into vague limitless polytheism or fetichism.

Ancient Dynasties. Before the Persian invasion Egypt had already seen, according to historic monuments, some 26 dynasties, and the Persian invasion took place some five centuries earlier than our Christian era. The world has learned the names and something of the doings of the leading sovereigns during those dynasties, for they are carved on the monuments which were erected all over the country. Little is known of the earliest among those dynasties, but with the fourth dynasty we begin to have the records of a civilisation which must have been absolutely unknown to any other part of the world at the same time.

Architecture began to flourish then in forms which Egypt has never since surpassed, in forms which few other countries from that time to this have ever excelled or equalled. Pyramids, temples, and other buildings arose and bore testimony to the marvellous architectural skill of their builders; statues were chiselled which could have held a fair rivalry with the work of Greek and Roman sculptors, and the paintings and inscriptions on the walls of Egyptian temples accomplished the work of history as well as that of art, for they not only prove the intellectual and artistic capacity of the workers, but they also tell to later times what the kings and rulers, the industry, commerce, and agriculture of the land had already accomplished and were accomplishing.

Dark Periods. There are intervals in the story of those dynasties where you find little or no trace of artistic culture or of history recorded in monumental buildings. It is evident that during those periods thus obscured there must have been great invasions, or other calamities, absorbing the whole strength and mind of the country, because after a certain lapse of time we find the historic monuments once again coming into existence and the Egyptians returning to their place in art and in civilisation. During some of these intervals of comparative darkness royalty itself seems to have been banished from the land. Under the kings of the twelfth dynasty it resumed its place, and the natural boundaries of Egypt seem to have been restored. The Egyptians must have had for their time a wonderful mastery of applied science. Under that twelfth dynasty was constructed an artificial reservoir known as Lake Moeris, which covered more than 60 square miles, the object of its creation being to regulate the overflow on the left bank of the Nile. Another sovereign undertook and accomplished the erection of the great pillared hall at Karnak, which is still regarded as one of the triumphs of Egyptian architectural art, and indeed of the world's architectural art.

Invasion of Shepherds. One of the most remarkable invasions which interrupted the succession of the regular dynasties was that which is known as the invasion of the shepherds about 2200 B.C. According to legend and such records as have been preserved, this was an irruption of a pastoral race, who, finding that the conditions of their own soil did not admit of prosperity, passed from Assyria into the valley of the Nile by the Isthmus of Suez, actually took possession of a great part of middle Egypt, and set up a realm of their own with its kings. This dynasty was established at Memphis, and built fortifications in order to prevent other hordes of immigrants from following their example and endeavouring to found realms in their turn. It is generally understood that it was one of those rulers to whom Joseph, the elder of the two sons of Jacob by Rebekah, was Minister. The Shepherd or Hyksos dynasty was ultimately expelled from Egypt, but some of the race still continued to be occupants of the Egyptian soil, and left their physical traces among the Egyptian populations.

After the expulsion of the Shepherds Egypt seems to have recovered her old art and civilisation, and again we begin to have the monumental records of passing history. One of the sovereigns of this restoration was Thothmes III., who conquered Western Asia and the Soudan, and is described in some lines carved on a monumental pillar as one "who set the frontiers of Egypt wherever he pleased." Another of these sovereigns is described by Greek historians as Memnon, the Son of the divine Aurora. The Greeks were now beginning to take a deep interest in Egyptian civilisation, and before long we shall find that some of their great historians set themselves to work to describe and explain its condition.

Inaccurate Historians. The Greek explorers were generally much inclined to explain everything they found in Egypt by some reference to the religion and the history of Greece, and were apt to invest the monuments and the other records which they found with a pervading aroma of Greek mythology. As they converted one of the Egyptian Princes into Memnon, the King of the Speaking Statue, which at the rise of every sun paid homage by salutation to Aurora his mother, so they described another Sovereign, Rameses II., as Sesostris. The Greeks, indeed, made a bold, and at the same time an easy, condensation of history by ascribing to this really warlike and brilliant Prince all the achievements in peace or war of many or most of his predecessors.

Rameses, or Sesostris, left behind him some great architectural records. To him are due the magnificent obelisks of Luxor, one of which was transplanted by modern invasion to the Place de la Concorde in Paris. Egyptian obelisks have undergone foreign transplantation in other instances as well as that of the column of Luxor.

One of the obelisks from Heliopolis was moved by the orders of Cleopatra to Alexandria, and in the course of time was conveyed from that spot across the seas and found a resting-place on the Thames Embankment in London. Yet another of these ancient monuments has been borne away from Egyptian soil and transferred to a site in New York. The human mind can hardly conceive a more curious transformation scene than that illustrated by the removal of an Egyptian obelisk from its place in the desert to a home in one of the newest, noisiest, and most crowded cities of the New World.

The Israelites' Task. The captives taken in war by the Egyptian sovereigns were commonly set to work at the erection and ornamentation of these monuments, and the Israelites, a large number of whom had endeavoured to settle comfortably in Lower Egypt, were drawn upon by the ruling power for the supply of workmen, not merely in the building of artistic monuments, but also at the opening of quarries, the making of bricks, and the raising of embankments to secure cities against inundation. Rameses III. was the last of the great line of rulers here described, and his deeds in war and peace are commemorated in a Temple at Thebes.

With the passing away of Rameses came an era of decline in the power of the Egyptian civilisation. One, and probably the main, cause of this decline was that the country had exhausted herself by attempting to spread her dominion too far. The Egyptian rulers had for generations been doing little or nothing to ensure the safety and prosperity of their own people, and were far too much given up to that ambition for the spread of territory which seems to be the weakness of monarchies all over the world.

Egypt might always have been prosperous and secure under the nourishing protection of her great river, and sheltered as she was by the surrounding desert regions from the frequent invasion of foreign intruders. But her kings were too often eager to spread their boundaries at whatever risk, and made it their ambition to obtain full control of the bordering sea, and for that purpose to spread their power over the whole of Northern Asia, and even to establish a settlement on the island of Cyprus. With this view they secured the military services of outlying populations, and thus became surrounded by foreign guards, who in time began to assert their influence as practical rulers of the State.

Ethiopian Invasion. The Ethiopians, or Cushites, took advantage of the opportunity given to them by these local discords to take possession of Upper Egypt. For half a century these Ethiopians ruled over the land which had known the dynasty of the Pharaohs. The Ethiopians were finally expelled from the country, but even the manner of their expulsion tended towards the decline of Egypt's independence, for it was in great measure accomplished by the Persians, who for a time made Egypt their own.

Egypt has never since been a self-ruling country. She was coming to be regarded by the outer world as a mere province of Persia, and was conquered by Alexander the Great, who founded the city of Alexandria, which helped to perpetuate his name. The Romans invaded the country, and ruled it for a time after the death of Cleopatra. Some 400 years after the Christian era Theodosius, the Roman ruler, issued edicts actually suppressing the religion of the Pharaohs.

From that time the story of Egypt becomes mixed up with that of Europe. We shall have to make many references to that story of Egypt during our historical narrative. We may say in advance that the opening up of the country to the commerce of the world by the creation of the Suez Canal was but the realisation of a dream which had been the fond hope of one of the Pharaoh kings, a dream he had attempted to realise many centuries before it was ultimately made a reality by the inspiration and the energy of M. Ferdinand de Lesseps, well within the recollection of living men.

The Assyrian Empire. The history of the Assyrians comes next in chronological order. The two great rivers, the Tigris and the Euphrates, come down from the Armenian mountains, where their sources are close to each other, and they surround in their course, before each pours its waters into the Persian Gulf, a large tract of country, mountainous at the one end and sandy at the other, to which history has given the name of Mesopotamia, meaning a region in the midst of rivers.

The earliest dwellers in Assyria included, in Chaldea, the Cushites, of whom we have heard during the story of Egypt's invasions and dynasties. In the mountainous part were the Turanians, and in another part of this vast territory were the Semitic population, coming of a white-skinned race whose origin cannot be traced back in history, and who have become celebrated throughout the world as the Assyrians, the Hebrews, the Phœnicians, and the Arabs. Assyria owned two of the most famous cities in the world, each of which in turn became the capital of the country, Babylon on the Euphrates and Nineveh on the Tigris. The walls of Babylon are said to have been 50 cubits thick, and to have stood nearly 400 feet in height.

Assyria, like most other regions in those days and in much later days, was made subject to many invasions, which its prosperity and its attractive situation drew upon it. The dynasty of the Pharaohs held the mastery of Assyria for some two centuries at least, but when the decline of Egypt set in the Assyrians released themselves from subjection, and took to invasion and annexation on their own account. They made war against the Hebrews, and their conquest of Hosea, the ruler of Israel, is recorded in the Bible.

To be continued

Group 24
PHYSICS
3
Continued from page 246

THE THREE LAWS OF MOTION

Our Conception of Motion Purely Relative. Newton's Three Laws: the First Law Fully Considered. Mass, Weight, and Speed

By Dr. C. W. SALEEBY

Our Ideas of Motion. Any assertion as to the speed of moving bodies in space, such as we were considering at the end of our last chapter, is purely relative, like every other assertion about motion which it is possible for the human mind to make. We mean that, relatively to the objects of the landscape, the train is moving in a certain direction at a certain rate. Relatively to another sign-post, the train is moving *backwards* at a greater rate, and so forth.

The man on the ship, or in the corridor of the train, is moving backwards relatively to the ship or the train, but forward relatively to the landscape. The solar system is moving towards Vega relatively to certain other stars which the astronomers use as sign-posts, just as the engine-driver might use the telegraph-poles. Concerning the absolute motion of anything no one has any knowledge whatever. Indeed, we must go farther, as Spencer proved, and declare that our very idea of motion is purely relative. When we think of the motion of anything we think merely of its motion relatively to something else. We delude ourselves if we fancy that we can even conceive of absolute motion. Taking any case imaginable, we find that we cannot conceive of the motion of anything save with reference to *something*. Even if we think of no material thing, we are compelled to conceive of motion as relative to points in space. The conception is equally relative whether the points be imagined to be empty or to hold sign-posts.

Kinetics and Statics. Thus, having determined the kinds of motion, and being persuaded that we speak merely of relative motion, we must observe certain of the means by which motion may be measured. Thereafter we may proceed to study the laws of motion. The reader must be reminded of the logic of our order of procedure. We have agreed that the fundamental part of physics is the study of forces. We defined what we meant by a force, and observed that there was involved in it the idea of motion. To that we had to devote some important paragraphs; and now we must proceed to discuss it at length. If the reader desires a special word to indicate the department of dynamics which is concerned with motion, that word is *kinematics* *; but this is not often employed. In its place we use two words—*Kinetics* and *Statics*. The first is the study of cause and effect as applied to motion, it being found that the effect is always proportional to the cause—the motion to the force that produces it; and the second is the study of the balancing or equilibrium of forces, so that the combination of forces, *i.e.* of powers which tend to cause motion, results not in motion, but in rest. Let us now consider the names of the units which are employed in the study of motion. We must have units for time and space—factors plainly involved in all motion—and a unit to express the amount of matter that moves, and other units derived from these.

Standards of Measurement. The unit of time, fortunately in use in all countries, is the *second*.

The unit of length we might expect to be the yard, or units derived from it, such as the foot or the inch. But nearly all countries have abandoned such absurd measurements—absurd because wholly arbitrary and inconvenient—and have adopted the *decimal system* for their units. As our methods of counting are based on this system (ultimately derived from the fact that we have ten fingers), it is obviously a matter of very great convenience to use it throughout. Hence the student of science in this country has to make the acquaintance of measurements which are familiar to every fortunate French child, and which are used by men of science everywhere "from China to Peru," but which are not yet in general use in this country.

The unit of length (the simplest kind of unit of space) is the *metre*. When used in England we need not add the accent, and we may pronounce the word in English fashion, with the *e* like the *ea* in "eat." The metre is equal to rather more than thirty-nine and a third English inches. Space, however, has three dimensions—physics knows nothing of a supposed fourth dimension—and so there are units of surface derived from the metre and units of volume similarly derived. The thousandth part of a metre is called a millimetre; the hundredth part, a centimetre; the tenth part, a decimetre, whilst ten metres make a decametre. Each of these words may be used with the adjective *square* or *cubic* before it to indicate measures of area or of volume. We may note one special name in wide use—that of the cubic decimetre, which is usually known as a litre.

The Unit of Mass. Next we must obtain a *unit of mass*, and this has been conveniently agreed upon in the following fashion. As one of the most common and important of substances, water is chosen, and is considered at its temperature of maximum density—*i.e.* when

* The kinematograph has taught everybody that kinema is the Greek for a movement; but unfortunately the fashion now is to spell the word with a c, and people pronounce the "c" soft, so that the meaning of the word is being made as obscure as possible.

its matter, or "stuff," is as shrunken as possible. This point is at 4° above the zero on the Centigrade scale—in which the zero is the freezing point of water. Our unit of mass is, then, *the mass of one cubic centimetre of pure water at the temperature of 4° C.*, and this is known as a *gramme*. This excellent unit yields sub-divisions and multiples as the metre does—the milligramme, centigramme, decigramme (one thousandth, one hundredth, and one tenth part of a gramme respectively), the decagramme, which has ten times the mass of the gramme, and so forth.

The reader will observe that, in the above account, the word *weight* would apparently make just as good sense as the word *mass*. Why, we may ask, should we not talk of a unit of *weight*—the *weight* of a cubic centimetre of water, and so on ?

Mass and Weight. Occasionally a strict sequence must be sacrificed in order that we may not leave the reader with an unexplained term or assertion ; and this is a case in point. We shall therefore deliberately anticipate a future chapter—that on gravitation—in order that the distinction between weight and mass may be made clear.

The mass of a body is the quantity of matter or stuff that it contains. Mass is a radical and unalterable property of matter ; the amount of stuff in a pound of lead is the same whether the lead remain on the earth or be transported to the moon. But though all matter has weight, weight is a property not radical at all, and still less is it unalterable.

Indeed, we may positively assert that the weight of a given mass of unchanging matter never remains constant for two successive seconds. This may well seem to be an absurd assertion, but its truth will become apparent when we consider upon what the weight of a given mass of matter depends.

Weight is Always Changing. Weight is none other than an assertion of the force of gravity, in virtue of which every particle of matter in the universe attracts every other. But this force varies at different distances between the masses of matter in question, and varies with the amount of mass concerned. Hence a pound of lead would weigh far less than a pound on the moon, far more on Jupiter or the sun, simply because the moon has much less mass than the earth, whilst Jupiter has far more, with the consequence that the force of gravity is much less on the moon than it is on the earth, whereas it is much greater on Jupiter. Hence the weight of any mass depends on the position in space of all the other portions of matter that exist : and, as these portions of matter are incessantly changing their positions, it follows that, as has been said, the weight of a given mass of matter never remains constant for two successive seconds, though the mass is absolutely invariable.

If gravitation were abolished, there would henceforth be no such thing as weight : but plainly the mass of the matter in the universe would be unaffected : the mass would be still there, unchanged, though its different portions would not possess that attraction for one another which expresses itself to us as weight.

Weight an Imperfect Standard. While this cardinal distinction must never be forgotten, we may, nevertheless, conveniently use *weight* as an indication of mass. Our experiments are conducted at the surface of the earth, where the force of gravity is, for practical purposes, quite constant—the earth remaining constant in mass, and no other large body interfering practically with its attraction for small bodies on its surface. Hence, since the weight of any body is most strictly proportional to its mass, provided that other factors are unchanged, we are free to estimate the mass or amount of matter in a body by means of its weight.

Nevertheless, this method is plainly imperfect, for we ought to be able to measure mass without reference to a variable thing such as weight. We should be able to determine the masses of two similar cubes of different substances by some other means than by weighing them. We should be able to do so if we had them in empty space, with no more weight than depended on their attraction for each other. This can be done ; but before we see how it can be done, we must study another aspect of motion, and attempt to find for it also a unit of measurement.

Speed. This aspect of motion is its *velocity* or *speed*. Now it is quite evident that when we think of the speed of any moving body—say a man running a race—we are combining the two ideas of *space* and *time*. When we say that an athlete has run a hundred yards in ten seconds we have indicated his average velocity or speed, because we have stated the factor of space—the distance run ; and the factor of time—the number of seconds taken in traversing that distance. Then if v stands for velocity, s for space, and t for time we can say that $v = \frac{s}{t}$, a simple formula which may be illustrated from the case already quoted. The total distance or space, divided by the total time, is 100 (yards) divided by 10 (seconds), and thus v, the velocity, must be ten yards per second—*i.e.* $v = \frac{s}{t}$.

Now we know that the speed of a moving body may undergo diminution or increase ; and under certain natural conditions, where the cause of the motion is constant and continuous in action, we find that this diminution or increase is regular.

If the rate of increase of velocity is regular, it is given a special name, *positive acceleration* (from the Latin *celer*, swift), and a regular rate of diminution of velocity is called *negative acceleration*. This use of terms may be confusing, and is in defiance of the derivation of the word acceleration ; so we shall do better to call increase of speed *acceleration*, and decrease of speed *retardation*. We note, again, that these are of interest and importance to us only in so far as they are regular. By this is plainly meant that during each unit of time—during each

second—there is a constant increase or diminution in velocity; as, for instance, when a body moves, in successive seconds, through 32 ft. more of space than it moved in each preceding second—dropping, say, 32 ft. in the first second, but 64 ft. in the next; so that at the end of two seconds it has passed through, not 64 ft.—as would have been the case had there been no acceleration—but through 96 ft. Later we shall have to return to acceleration and retardation, in especial relation to the force of gravity.

But now, having understood what is meant by velocity, we are in a position to return to the problem already stated—as to the possibility of measuring the mass of bodies without weighing them, and in a manner which is wholly independent of the fact that they have weight.

The Action of Force. We find that a given force, acting on a given mass for a given time, always produces the same velocity; hence two different bodies—one, perhaps, "light" and bulky, the other "heavy" and dense—can be shown to possess the same mass, *if the same force, acting on each for the same period, imparts to each the same velocity.*

By combining in a different way the definitions already noted, we can obtain a measure of force and a unit of force. For we can measure a force by the velocity which it imparts to a given mass when applied to it for a given period of time. The unit of force is called the *dyne*, and is that amount of force which, applied for one second to a gramme, imparts to it a velocity of one centimetre per second.

And now at last, having defined force and motion, and having agreed upon modes of measuring them, we are in a position to study the laws of motion.

The basis of the science of kinetics consists of three laws enunciated by Newton and known as Newton's laws of motion. He himself called them *axioms or laws of motion.*

Sir Isaac Newton. The formation of these laws is scarcely less important than the discovery of universal gravitation and the law of its action, which Newton also achieved. Sir Isaac Newton was born in Lincolnshire in 1643, his father being the lord of Woolsthorpe Manor. He was reared with great difficulty, having been prematurely born. For some time he had to help his widow mother with her farm, and he left school at Grantham for this purpose, but at the age of seventeen he was allowed to go to Cambridge University, which counts him as incomparably the greatest of her sons in sheer magnificence of intellect. At Cambridge he made most signal discoveries in pure mathematics, which, however, do not greatly concern us here. In the terrible year 1665, when he was twenty-two, the marvellous boy, who had already made an immortal name, was compelled to leave Cambridge owing to risk of the plague, and it was then that the fall of an apple from a tree in the family orchard led him to the discovery of gravitation.

His mind, by the exercise of its supremely great scientific imagination, "leapt from a falling apple to a falling moon." At the age of twenty-three, the boy who had already discovered "how the heavens are balanced" proceeded to demonstrate the fact that white light consists of a combination of rays of light of many colours.

His chief work, the *Principia* (the translation of the full title is "The Mathematical Principles of Natural Philosophy"), was finished in 1686. Six years later the results of years of work were destroyed by the overturning of a lighted candle by his pet dog "Diamond."

Newton died in 1727, and was buried in Westminster Abbey. He spent the greater part of his eighty-four years, as has been finely said of him, in

"Voyaging through strange seas of thought
alone."

The Laws of Motion. Newton's Laws of Motion are enunciated in his *Principia*. The Latin may be thus freely translated so as to reduce the laws to their simplest and most intelligible form:

1. If a body be at rest, it will remain at rest unless it is compelled by some external force to change its state; and similarly if it be in motion, it will continue to move in a straight line and at a uniform velocity for ever, unless its state of motion be affected by some external force.

2. Change of motion of any body is proportional to the external force that causes it, and takes place in the straight line in which the force acts.

3. To every action there is always an equal and contrary reaction; or, the mutual actions of any two bodies are always equal and oppositely directed. This law is often briefly stated thus: Action and reaction are equal and opposite.

Fully to illustrate and apply these laws and the deductions from them would be practically to state the science of dynamics, including both statics and kinetics, in a perfect and final form. We must devote, at least, many pages to their consideration.

The first law is the simplest and the most important. It expresses the property of matter which is often called *inertia*, implying that "matter is passive, or has no power in itself to change its state, whether of rest or motion." This sentence, quoted from a well-known text-book, is however, an inaccurate expression of the property of inertia. We who have lately become familiar with radium and radio-activity are aware that matter is very far from being "dead" or "passive," and that it contains sources of energy till lately unsuspected. But the principle of inertia may be expressed as meaning that the state of rest or motion of any body can be changed *only in virtue of the action of a new force.*

Inertia. Common experience has taught us that tumblers do not fall off tables "by themselves," that, in general, things stay where they are unless something moves them; and we say that this characteristic of things is due to their *inertia*, which seems to us to be the most

natural thing in the world. The observed facts of material nature are often used as foundations for figures of speech, as when we speak of the inertia of a man's mind, or of a political party. But the present writer has not yet met any metaphorical use of the fact that inertia is expressed in two ways, each of which Newton stated in his first law of motion. That law states not merely that a resting body remains at rest until some force causes it to move, but also that a moving body continues to move *for ever* in a straight line at a constant velocity until some external force is applied to it. Now this property of " going on " when once started is as much a result of inertia as is the remaining at rest when at rest. In each case the body in question—we assume for the moment that no new force is being evolved inside it—is passive; passive, though it be a "flying star" like Arcturus, rushing through space at the rate of one hundred miles a second. It is *force* that causes the motion—not Arcturus, which is as inert, so far as this motion is concerned, as is a penny lying on a mantel-shelf. The one moves, the other rests—each in virtue of its inertia. When writers in general become acquainted with the elements of physics and gain a full appreciation of the principle of inertia, instead of being content, as at present, with the mere recognition of one of its results (which must be quite incomprehensible to them), they will discover that both aspects of inertia may be illustrated from the ways of men as individuals or in society.

Mental Inertia. If it be mental inertia that causes a man to resist a new idea, it is also mental inertia that causes him to persist in following an old idea, long after any rational cause for following it has ceased to exist. Illustrated in daily life everywhere, this kind of mental inertia is conspicuous in children, the aged, and the insane. This is as truly inertia, and as truly due to the same cause—the lack of any spontaneous force within the person in question—as is the inertia that is expressed simply in continuing to do nothing simply because one never has done anything.

We lay emphasis on this analogy, because it is neglected, true, and useful. If we condemn the inertia of the more obvious kind, we should equally condemn the less obvious inertia which expresses itself in human action as the aimless continuance of a course once entered upon. Each is equally due to mental laziness, passivity, or inertia, and each illustrates Newton's first law of motion in the sphere of mind.

We hope we have convinced the reader that the second part of the law really expresses and depends upon the same fact as the first. But the reader may admit this in theory, but deny that, when we come to the test of actual experience, the second part of the law is found to be true. It is, of course, its apparent untruth that has led to the non-recognition, by the public and the writers, of the more subtle expression of the principle of inertia. For, in point of fact, all the moving bodies with which we are familiar show a tendency to stop moving: whereas Newton's law declares that the fixed and universal tendency of all moving bodies is to go on moving. If the law is contradicted by a single fact, it is no law but a lie; and we must ask ourselves whether the thousands of familiar facts that appear to contradict it really do so.

Why Does a Cricket-ball Stop? A cricket-ball, driven with moderate force along the ground, will reach the boundary at Lord's when the ground is hard and dry and the grass cut short. The critics remark that "the outfield is very fast to-day." The same drive, applied to a ball of the same weight, after a night's rain, will send the ball only to a point short of the boundary by many yards. Everyone knows why the ball stops—" the outfield is slow to-day." When the cricketer uses these terms he is virtually recognising the second part of the first law of motion. He admits that the ball stops short of the boundary in the second case, not because of any tendency to stop, but because *something stops it*. He knows very well, too, that the same drive would cause the ball to run for hundreds of yards if the outfield consisted of a very smooth sheet of ice. In such a case the ball would not roll, but would slide, and there would be very little sign of any tendency to stop.

The difference between the firm turf outfield, the wet outfield, and the ice outfield (on which any drive that passed the fielders would be worth a hundred runs, if there were no boundaries), lies in the differing values of the external forces of *friction* in the three cases. In the last case, the force of friction is so slight that the ball does not roll, but glides or slides. It is, of course, friction that makes the ball roll in actual practice. Abolish friction and the ball will glide for ever, if there be no other force to stop it. In point of fact, however, the ball would not roll for ever, even on the smoothest ice, and even if its own surface was as smooth, so that friction was reduced to a minimum. It would not roll for ever, even if the conditions were such (quite unobtainable in our experience, whether of cricket or any other form of practical dynamics) that there was no friction at all. The ball would stop at last. This would not be because of any tendency to stop, but simply because of the resistance of the air.

The Ocean of Air. Remember that the air is really an ocean, at the bottom of which we crawl and play cricket. The hardest drive would not send a ball far through water; the hardest drive will not send it infinitely far through air; but, in virtue of the fact of inertia, the feeblest drive would send the ball moving at undiminished speed—it matters not how slowly—for all eternity, if there were no friction and no resisting medium.

The apparent tendency to stop must thus be recognised as consisting in the interference of friction and the resistance of the medium with the real tendency—the tendency to go on. But we may note one or two further facts concerning the resistance of the medium.

It has this character, that it increases with the velocity of the moving body. This is a physical fact which is unalterable, and as

such it enables us to make certain predictions as to mechanical possibilities. For it follows from this fact that there must be limits to the velocity attainable by a ship moving through the ocean of air, or a ship moving partly through an ocean of air and partly through an ocean of water. The two cases are exactly parallel. In each the difficulty of maintaining a velocity increases as the velocity increases. If a given "horse-power" or strength of engine will yield a given velocity, twice that strength of engine will *not* yield twice that velocity. The same principle applies to the speed of projectiles.

The Spinning Top. The second fact to be noted is that the resistance of the medium—however invisible the medium may happen to be—and however unimportant, as compared with friction, it may be in the case of the cricket-ball, is yet easily demonstrable by a simple experiment, and is found to be very considerable. A heavy metal top will spin in water for only a very short time. In air it will spin for perhaps twenty minutes. Here friction is slight, since the point of contact between the top and the surface is so small. (Try spinning the top on india-rubber—or cheese.) If now the top be spun in a "vacuum"—that is, in a vessel from which the greater part of the air has been removed—it will spin for an hour. Abolish all friction and all resistance from air, and the top would spin *for ever*. Plainly, then, the reader will say, perpetual motion is theoretically possible, though men of science declare that it is not.

There is here an apparent contradiction, but it depends upon a misuse of language. Newton's first law of motion positively declares not merely that perpetual motion is possible, but that it is inevitable and necessary. Every moving thing, it declares, will exhibit perpetual motion if only it be left alone.

Perpetual Motion. But a special meaning has been attached to the phrase perpetual motion, and we must explain that meaning here, since it bears directly upon Newton's laws of motion, and since Newton recognised indirectly, in virtue of his study of motion, that law of the conservation of energy which contains a denial of the possibility of so-called perpetual motion. We have seen that perpetual motion is as natural and necessary—so far as the laws of nature are concerned—as perpetual rest. Each implies the basic principle of inertia. But by so-called "perpetual motion" is meant not perpetual motion at all, but the production of perpetual work by motion, *without any loss or disappearance of that motion*—a very different thing.

As long as motion remains motion it will be perpetual; and, indeed, it may be shown that motion is perpetual, since even when the motion of a body *ceases* it is not *annihilated*, but is really transformed into other forms of motion. Otherwise it would not cease, declares Newton's first law.

The cricket-ball stops rolling, but its motion has been communicated to innumerable particles of air which it has displaced, and has also expressed itself as heat (which is a mode of motion) engendered by the friction between the rotating ball and the ground, and the rotating ball and the air.

Motion Cannot be Destroyed. It would be a case of what is so badly named perpetual motion if the cricket-ball caused all these motions in its path—did all this work—and yet lost none of its own motion. If it were prevented from doing any of this work, it would display perpetual motion in its own body; but in doing work, that is, in imparting motion to its surroundings, it loses its own motion. What is meant, then, by the "impossibility of perpetual motion" is really no such thing: nothing but perpetual motion is possible to any moving thing, unless it bestows its motion to something else. It simply cannot stop save by giving up its motion to something. It cannot destroy its motion. By the *impossibility of perpetual motion* is meant the fact that the cricket-ball cannot *both give up its motion and retain it*. One cannot both eat his cake and have it. One cannot make something out of nothing, nor destroy anything—not even motion. Motion may be got rid of, but it remains somewhere. This is what is meant, as we shall see later, by the law of the conservation of energy.

The Conservation of Energy. Energy—including the kinetic energy we call motion—cannot be created or destroyed. When the ball left the bat, *something was put into it*. The bat lost part of its motion, which the ball gained. If the ball had a tendency to stop, this would mean that the something put into it had a tendency to be annihilated. But there is no such thing as annihilation. The something imparted to the ball remains with it after one yard, and will remain with it throughout an eternal passage through infinity, unless it is transferred to something else.

It must continue to exist somewhere. But if it be imparted to something else—*e.g.* the air or the turf—it necessarily leaves the ball; and so the ball stops. It follows that the ball can do no work without giving up something it possesses. It can do no work without *doing* it. That is what the perpetual motion machines are designed to do: their makers expect them to do work without doing it; to create power out of nothing; to give their motion to a lever or a wheel, and yet to keep it.

We have insisted upon these considerations at length, first because the phrase *impossibility of perpetual motion* is the very worst conceivable way of expressing what it is meant to designate, whilst the utter impropriety of the phrase is let pass by writers in general; and because it is very important, and not sufficiently insisted upon in the text-books, that we recognise the necessary connection and interdependence of Newton's First Law of Motion and the law of the Conservation of Energy. The former is now to be regarded as none other than an expression of a special case of the latter. The law of the conservation of energy includes the fact of inertia.

To be continued

Group 27

SHORTHAND

3

Continued from page 2..

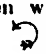
SHORTHAND

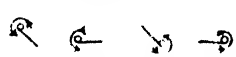
Third Instalment of the Special Course taught on Pitman's Twentieth Century Plan, dealing with Circles, Loops and Grammalogues

By SIR ISAAC PITMAN AND SONS

THERE are in the English language a number of frequently recurring combinations of consonants which are represented in Pitman's Shorthand by large circles, loops, and hooks, attached to the consonant stems. After the student has learned the use of the additional sign for *s* (a small circle) in the following section, he will begin to master the series of abbreviations above mentioned. The systematic and general employment of hooks, etc., for doubling and trebling the power of consonant characters forms a distinguishing feature of this shorthand method. The signs can be mastered with comparative ease, and their uniform employment under simple rules, and the readiness with which they can be written, render them an important addition to the speed resources of the system.

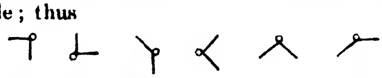
Circle S and Z. *S* (together with its heavy sound *z*, for which *s* is generally written) is one of the most frequently occurring consonants in the English language. The consonant *s* is represented, not only by the stroke), but also by a small circle (○), which forms an easy means of joining one consonant to another.

When the circle stands alone, or is joined to straight consonants not forming an angle, it is written with the backward or LEFT motion, thus 



sp, *sk*, *ps*, *ks*.

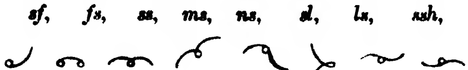
Between two straight lines forming an angle, the circle *s* is written on the OUTSIDE of the angle; thus



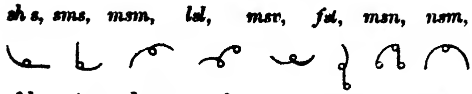
kst, *tsk*, *pst*, *chsp*, *rsp*, *rsk*.

When the circle *s* is joined to curves, it is written inside the curve, and when it occurs between two curves, it is usually written inside the first; as

sf, *fs*, *ss*, *ms*, *ns*, *sl*, *ls*, *ssh*,

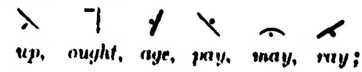


sh s, *sms*, *msm*, *lsl*, *msv*, *fsl*, *msn*, *nsm*,

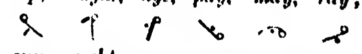


fsk, *tsn*, *lsm*, *msls*, *nsng*, *ssts*, *slsts*, *lsr*.

The circle *s* is always read *first* at the beginning of a word, and *last* at the end, the vowel or vowels being read according to their positions with regard to the stroke consonant, and not with reference to the circle, as



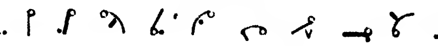
up, *ought*, *age*, *pay*, *may*, *ray*;

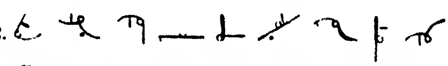


sup, *sought*, *sage*, *pace*, *mace*, *race*.

The succeeding Exercises when in shorthand are to be transcribed in longhand; when in ordinary print they are to be written in shorthand.

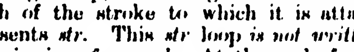
EXERCISE.

1. 

2. 

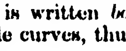
1. Soup, snow, cars, keys, psalm, seed, bees, alms, thaws.
2. Upset, musk, deceit, opossum, tears, beseech, oxide.

Loops ST and STR. The frequently occurring combination *st* at the beginning of a word, as *stem*, and *st* and *zd* at the end of a word, as in *mist*, *mused*, are represented by a loop made half the length of the stroke to which it is attached. This *st* (stee) loop follows the same rule as the circle *s*, that is, it is always read *first* at the beginning of a word, and *last* at the end; like the circle *s* it is written *backward* to straight letters and inside curves; thus



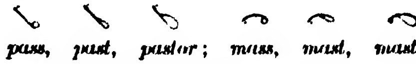
ache, *sake*, *stake*; *Kay*, *case*, *cased*.

When convenient the *st* loop may be employed medially, thus



vestry, *testing*.

A large loop, extending two-thirds of the length of the stroke to which it is attached, represents *str*. This *str* loop *is not written at the beginning of a word*. At the end of a word it is invariably read *last*. The same rules for writing apply to it as to the circle *s* and the loop *st*, and it is written *backward* to straight letters and inside curves, thus



pass, *past*, *pastor*; *mass*, *mast*, *master*.

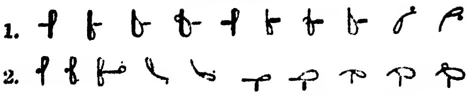
This loop may be used medially, as in

masterpiece.

The circle *s* is added to a final loop, as in the following examples,

taste, *tastes*, *lustre*, *lustres*.

Exercise.

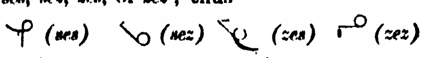


1. Steep, post, stick, kissed, stuff, foist, statue, statute.
2. Jest, jester, jesters, elastic, pastor, foster, Chester.

Large circles SW and SS or SZ. A large INITIAL circle written in the same manner as the circle *s*, represents the double consonant *sw*, thus

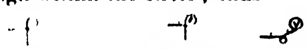
seat, sweet, sum, swum. but *sway, swaying.*

A large MEDIAL or FINAL circle, written in the same way as circle *s*, represents *ss* or *sz*. This large circle may be supposed to contain the second-place short vowel *e*, and thus to represent *ses, sez, zes*, or *zez*; thus



necessity; passes; possessive; causes.

Other vowels may be expressed by placing the vowel-sign within the circle; thus

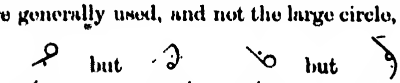


exist (ek*zist*), *exhaust, exercise.*

Final *s* is added by continuing the circle; thus

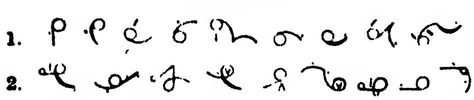
exercises.

When a word has a final accent, the stroke *s* and small circle or the small circle and stroke *s* are generally used, and not the large circle, thus



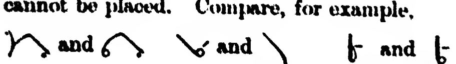
ra'ces, but *recess'; pa'ces,* but *possess'.*

Exercise.



1. Switch, Swedish (*sh* up), swing, swill, swiftest, swivEL.
2. PossessoR, accessory, unsuccessfuL; roses, anaLysis.

Vowels and S and T. As an initial circle or loop must always be read *first*, and a final circle or loop must always be read *last*, it is necessary, when a word begins or ends with a vowel, that stroke consonants be employed, and not circle *s* or loop *st*, to which vowels cannot be placed. Compare, for example,

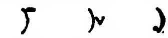


asleep, sleep; puss, pussy; dust, dusty.

Therefore,

The STROKE consonant must be used—

(*a*) When *s* or *z* is the only consonant in a word, as

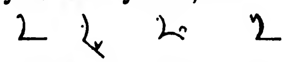


saw, sigh, easy.

The stroke is also employed in derivatives from such words, as

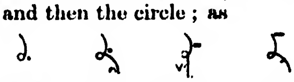
sawmill, sighing, easiness.

(*b*) When a word begins with a vowel immediately followed by *s* or *z*, as



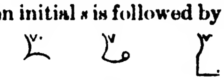
ask, espy, assume, Isaac.

(*c*) When a word begins with *s*, followed by a vowel and another *s* or *z*, the stroke *s* is written and then the circle; as



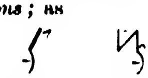
cease, seizure, society, saucer.

(*d*) When initial *s* is followed by two vowels, as



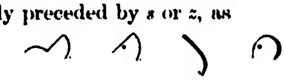
Siam, science, sciatica;

or when final *s* is preceded by two vowels *in different positions*; as



joyous, tortuous.

(*e*) When a word ends with a vowel immediately preceded by *s* or *z*, as

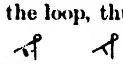


mercy, racy, busy, lazy.

(*f*) When a word begins with *z*, the stroke) is written, thus

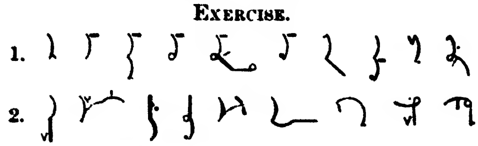
zero, zeal, zigzag.

When the last consonants in a word are *s t* with a vowel between them, and when a vowel follows *s t*, the circle *s* and the consonant *t* must be used, and not the loop, thus



rosette, rusty.

Exercise.



1. Ace, essay, says, espouse, schism, assize, assignee.
2. Dizzy, cosy, rosy, russet. suicide, scissoRS, easel, zenith.

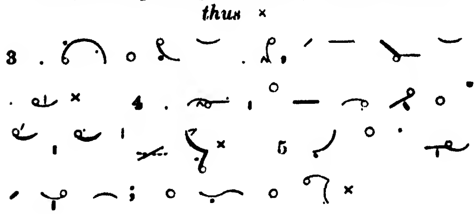
Grammalogues. Frequently occurring words are expressed in shorthand by one of their letters, as ╲ for ╲ *be*. These words are called grammalogues or letter-words, and the shorthand characters that represent them are called logograms or word-letters. Below is given a list of grammalogues which should be committed to memory. These characters are generally written on the line, but often above or through it. The position in which they should be written is indicated thus: (1) *above* the line; (3) *through* the line; all others rest *on* the line.

GRAMMALOGUES.

a, an (1)	*he*	*shall*
all (1)	*him, may*	*should*
and (1up)	*how*	*the*
any, in (1)	*I, eye* (1)	*them*
are	*is, his*	*these* (3)
as, has (1)	*it*	*this*
be	*me, my* (1)	*those* (1)
but	*of* (1)	*to*
can (1)	*on* (1)	*who* (down)
first	*our, hour* (3)	*was*
give	*put* (3)	*why* (1)
have		*you*

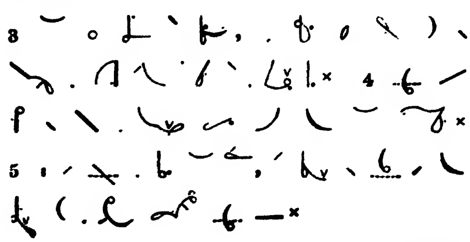
EXERCISE.

The full stop is represented by a small cross; thus ×

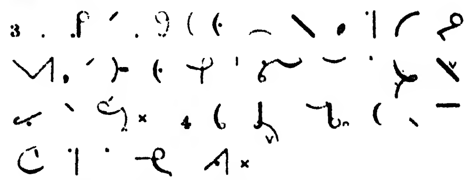


Grammalogues are printed in italic.

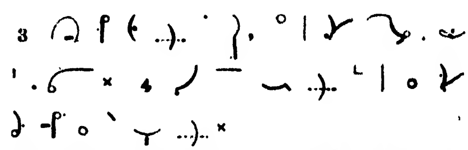
3. Sam *is* FULL *of* dismay *in* passing *the* Bay *of* Biscay. 4. *But my* Scotch gillie shows *he has* no FEARS, *and my* Sepoy *has* no SCARE *as to his* safety. 5. *Can you* say *how I may* pacify Sam *on* this SCORE? 6. *Why you may* assure *him he has* no cause *to give* way *to any* ALARMS, OR speak *to him in* such ways *as* seem likely *to* allay *his* SORROWS.



3. *A* king's ministers occupy HIGH posts; they *can* speak *first, and* they *may* make OR MAR *the* peace *of the* rest. 4. If chosen by vote, *those who have the* power *to* register such *a* vote *should* use *it to put in* office just advisers *and those* honest *in* counsel. 5. By *these the* head *of the* state *may be* safely advised, *and in this* way *his* rule *may be* fixed.



3. At *the* desire *of Lord* Swanage, they wrote essays *on* Genesis. 4. *The* successful essay bore *the* name *of* Thomas Davis. 5. Many were FULL *of* ERRORS, *but the* master seems *to think* highly *of* Davis's *as* possessing many excellences. 6. *A thing given* by many *was a* synopsis *of the* book.



3. Cecil *can* now *see it is of* no *use to* assail *the* lessee *who is* honest, *and to whose* honesty *all of us can* testify. 4. If we *may* say *so, he* ought *to be* less zealous *to* abuse *in so* fussy *a* way such *an* unassuming fellow. 5. *To use him* thus *is to* show *a* sauciness *which is* wrong. 6. Only *a* ninny *can* pursue *it in so* testy *a* style.

KEY TO EXERCISE IN LAST LESSON.

Long Vowels.

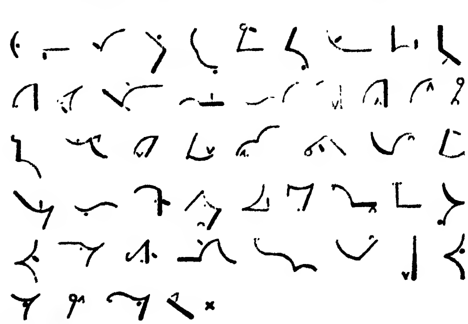
She, thaw, hay, oath, bay, go, each, woe, shoe, mow.

Short Vowels.

Lack, red, tap, rag, ditch, pill, dell, mill, ledge, knock, jug, chop, cook, gum, fop, wood, lock.

Long and Short Vowels and Diphthongs.

Goal, get, love, loam, beach, ship, chime, joy, pouch, ague, allow, boil, windy, mire, pad, wide.



To be continued

Group 1
AGRICULTURE
3
Continued from page 298

CULTIVATION OF THE SOIL

Ploughing, Harrowing, Cultivating, Rolling, Pressing, Sowing. Drainage of Soils. The Value and Composition of Manures

By Professor JAMES LONG

The Ideal Form of Cultivation. The soil is tilled either by hand, horse, or steam power. The chief object in view is the formation of a seed-bed, the mould composing which should be reduced by weathering and the aid of farm implements to as fine a condition or tilth as possible. Owing to their extreme fineness and delicacy, the roots of plants are unable to penetrate as they should in all directions unless the mechanical condition of the soil approaches perfection.

The cultivation of soil has the effect of bringing most of its constituents into contact with the air and the sun, by which means it is better adapted to the feeding of plants, while its texture is improved. The ideal form of cultivation is spade labour, but this is impossible on the farm owing to its great cost. With the spade or the fork the surface of the soil is completely turned, broken up, or laid up in loose clods for pulverisation by sun and rain, or frost, whereas the subsoil may be also dug or loosened without being brought to the surface.

It is owing to the influence of the elements that trenching or double-digging proves so valuable in nursery and garden work. The oftener the subsoil is moved, while kept in its place, and the more it is in this way exposed to air and sunlight, the more rapidly is it improved, and the greater the extent of the feeding ground of the plants which grow above it. The plant food present in the subsoil, practically the second nine inches below the surface, is chiefly present in an unavailable form, but as its future availability depends chiefly upon air, heat and moisture, it is obvious that digging is superior to ploughing, and the subsoil plough, which, unlike the ordinary plough, keeps the subsoil in its place, should be used as often as possible.

Ploughing. Arable land is, in the first place, cultivated solely with the *plough*, which is made in a variety of forms which are described in a succeeding chapter. It is seldom that the farmer ploughs more than nine inches deep or more than a foot in width. As a rule, the greater the depth, the narrower the furrow, for both width and depth increase the draught. It is, too, in most cases, especially where the surface soil is shallow, dangerous to plough too deep in practice, inasmuch as the inferior subsoil would be brought to the surface.

Plants which, like wheat, oats, roots, potatoes, lucerne, and the clovers, are deep-rooted, travelling both laterally and below in search of food and water, prefer deep soils. Barley and other shallow-rooted plants are successfully grown on thin soils where deep ploughing is impossible, but where deep stirring is sometimes essential. The area covered with the plough in a day varies from half an acre on the heaviest clays to one acre on the lighter soils, but this is ruled by the depth to which the plough penetrates, the horses travelling more or less rapidly in accordance with the draught. The form or shape of the furrow to be ploughed should be studied. The object in turning a furrow is to provide space for air beneath, to prevent the further growth of the plant life still growing on the surface, and to present a crest on each furrow, which, in response to the harrows, will work down into a fine seed-bed.

Furrow-slicing. Where land is ploughed in summer for cleaning, or in winter for frosting, high-crested furrow slices are important, as they weather better, and consequently pulverise more completely. It is important, where the soil ploughed is covered with vegetation, that the skim coulter should be attached to the plough, that it may pare the edge of the slice on the land side, and thus remove and bury those plants which, after the furrow has been laid, would otherwise remain partially exposed and in contact with the atmosphere, and thus be induced to continue their growth. The bottom of the furrow should be left flat, and here the horses walk when harnessed in single file.

In Canada and other Colonies gang ploughs are used, so that three furrows may be taken at one working, the driver riding behind his team. This practice is most economical and rapid, but adapted only to large fields. Three-breasted ploughs are seldom used in this country, while double-breasted or double-furrow ploughs are more common for work on hillsides; where the *one-way* or turn-wrest plough is also found most useful. Soil under the plough, unless where it is exceptionally light, is laid up in "lands," or ridges, with open furrows between them for carrying off the water. These lands vary in breadth from the width of a 13-coulter drill upwards, this width depending upon the soil texture. Thus, the heaviest clays are ploughed in lands of 11 or 12 feet, and being crested, or laid up, much higher than the furrows, they remain more or less dry during the winter season. It is essential that all such soils should be underdrained.

The Steam Plough. The steam plough has not proved a very successful aid to British farming; apart from its cost and the damage which follows the movement of the engine on the headlands of the fields, the implements are too clumsy as well as too risky; their work is therefore imperfect and sometimes more or less destructive. There are, however, occasions when fields which have been abandoned

to nature, or which are crowded with weeds, may be steam-ploughed with advantage. Where land has been ploughed with horse power, the steam cultivator may sometimes be used with great success. There is little risk of the subsoil being brought to the surface, while the rapidity and power with which the implement is drawn through the field assists in the reduction of the tilth and the destruction of weeds. The mould-

LINCOLN RED BULL

ing, ridging, or double-breasted plough is employed in forming ridges on which mangels and swedes are grown, and also for covering potatoes, which, planted in the furrow, are subsequently ridged over.

The soil, first ploughed deep, is brought to a fine tilth, especially necessary for the potato, and subsequently ridged throughout with the ridging plough. Manure is placed in the furrows, the potato sets are laid in their places, and the ridges between each furrow are split in two, and the furrows covered, forming in turn fresh ridges or *bouts*. The steam digger, which for some time promised success, has not yet taken hold of the farm. The latest invention, however, in which horizontal discs are introduced into the soil, stirring and pulverising it to considerable depth without turning it over, is suggestive of a marked advance, and possibly when the cost of the implement comes within the range of the farmer's pocket, it may be employed with advantage.

Harrowing and Cultivating. The cultivation of the soil by the aid of the horse *Cultivator*, *Scuffler*, *Grubber*, *Scarifier*, or *Horse Hoe*, is intended to improve the tilth by reducing it to fineness, and removing the weeds. These implements, some of which are large and powerful, are provided with bent pointed tines, which are sometimes shod with arrow-pointed heads or hoes, the horse-hoe in its turn being shod with L-shaped heads or shares. In this way coarse cloddy land is broken down and partially cleaned, but no implement, indeed, no form of labour, produces the same result as sun, rain, and frost, when the land is taken at the right moment. The horse-hoe is especially employed in hoeing between rows of beans, potatoes, mangels, swedes, and cabbages. It not only improves the surface tilth, but cuts down all weeds before it.

Land is harrowed after the plough to produce fine tilth in the seed-bed, and, whether sowing with the drill or the seed-harrow or by hand, with the object of covering the seed. Seed-harrows are lighter and smaller than harrows intended to follow the plough, but the weight depends upon the nature of the soil, for the heavier the soil the heavier the harrow required. In early spring the harrow is frequently drawn across a field of growing corn to kill young weed seedlings, as well as to break the crust which has formed, and to admit air. Similarly, harrows are drawn across meadows before the spring grass commences to grow, for the destruction of moss, the breaking of the soil cap, and the admission of air. Some farmers harrow their turnips as well to improve the tilth as to remove a number of the growing plants which, sown thickly in rows, are subsequently singled with a hand hoe, leaving spaces of 15 to 20 inches between each turnip. In autumn the stubbles are harrowed to kill weeds, and on those farms where *Trifolium incarnatum* (crimson clover) is grown, in order to cover the seed which has been broadcasted.

Rolling, Pressing and Sowing. Rollers are made in two forms—flat, and with a series of loose rings. Both are intended to give compactness to seed beds. After harrowing in the seed, whether corn, clover, or grass, the roller is passed over the land, moisture is preserved, the seed is induced to germinate better, and

GUERNSEY COW

the plant to grow more quickly, while the soil surface remains level and consequently more suitable for ulterior forms of labour. Grass land is rolled after harrowing to give the compactness which has been disturbed by the harrows, as well as to crush excrescences or loose materials, such as stones, which had not been picked up, in order that they may not be in the way of the knives of the mow-

ing machine, and possibly become a cause of accident.

The *Presser*, which is now employed in few parts of England, is drawn after the plough over land intended for wheat. The heavy rings of which it is composed produce deep, if narrow, furrows or impressions, into which broadcasted seed falls, and where it is subsequently covered by the harrows and roller. Although the seed of corn

ABERDEEN-ANGUS BULL

is frequently sown by hand, the prevailing method is now to deposit it in the soil by the aid of a *drill*. The two leading types of drill are those which are known as cup and force feeding drills respectively. The quantity of corn to be sown is regulated, and dropped into the furrows made by the tines of the cylinders, which are known as coulters. The average drill will not only sow corn, but clover, lucerne, peas, and in some cases beans and grass seeds. Grass and clover seeds when mixed are commonly broadcasted by the aid of a seed-harrow, which takes a wide sweep. Sometimes, however, a broadcaster is attached to an ordinary drill, so that grass seeds may be sown with the corn, and, therefore, at one operation. Drills are sometimes made with interchangeable bodies, so that turnip, mangels, and cabbage seed, together with artificial manures, may also be sown with the one machine. The

RED-POLLED BULL

HIGHLAND BULL

typical English drill is much inferior to the Canadian, which is lighter, requiring less horse power, and only one man and a boy—sometimes a man will suffice—instead of two men and a boy. The work is more quickly performed, the wearing parts are simpler, and easily replaced, while the ground covered in a day is measured.

Drainage of Soils. Unless drained effectively, many soils, especially the clays and marshy lands, would be useless for the production of crops. Land needs draining when it is boggy, when rain collects on the surface, or when the water table is so near the surface that the roots of plants penetrate it. A wet soil is often recognised by the weeds which grow upon it, as the sedge and the rush. Draining has the effect of removing surplus water, and of introducing air, consequently it promotes warmth, the soil becomes porous, is healthier for stock, and is followed by the disappearance of water-loving weeds, and the vigorous growth of

WELSH BULL

cultivated plants. The natural growth of crops is earlier, manures act more effectively, the soil is worked more easily, and a more perfect seed-bed preparable. Land may be drained on the surface by making grips or furrows—a common practice on very heavy clay where each "land" is ploughed to the width of the drill; by opening furrows with the spade, and filling with hard bushes, or—and this is the most approved practice—by laying pipes. The common drain pipe, 2¼ inches in diameter or bore, is made of

well-baked clay. It must be laid on a level bed, carry its water into the main drain, which conveys it to a carefully-selected outfall.

The depth at which the pipes are laid depends upon the character of the soil; it varies from 2½ feet in heavy clay to 4 feet in loam. The distance from drain to drain also varies with the soil from 12 to 40 feet. The main drains are laid lower than the collecting drains that the water may be perfectly collected and carried away. The main object of draining is not to remove water from above, but from below, and thus to reduce the height of the water table. It was found at Rothamsted that when the rainfall reached 25 inches some 2,500 tons of water were deposited per acre, of which less than 50 per cent. was evaporated, the balance passing through the soil; it follows, therefore, that on a soil which is not sufficiently porous or well-drained successful cropping is impossible.

The farm student, having learned the principles of draining, should make a point of studying it in actual practice. Especially should he also make a point of examining land which is undrained but which needs draining, and of heavy clay land with crops upon it which has been successfully drained.

MANURES

In order to understand the principles upon which farm production is based, it is necessary to realise that plants feed, and that just as the bodies of animals, including man, are built of materials found in the soil, the atmosphere, and in water, so are the bodies of plants. The plant, either directly or indirectly, feeds the animal, hence the dependence of the one kingdom upon the other, for the waste or excreta of the animal returns to the soil, and after undergoing certain chemical and other changes, becomes food for plants. Manure may be broadly divided into two kinds, farmyard dung, *i.e.*, the solid and liquid excreta of animals, and artificial manures, some of which are bye-products, while others are obtained direct from the soil itself. Farmyard manure is a mixture of the excreta of the livestock of the farm and straw and other litter provided for their comfort. It is the most perfect manure, because it contains all that is necessary for plant life, and because of the mechanical, or physical, action which it exerts, especially on the extremely light and heavy soils. In the consumption of food by stock, whether corn or cake, hay, straw, or roots, only a portion of the nutritious material is utilised, the remainder is evacuated, and as this refuse contains the larger proportion of the fertilising matter present in the ration, it follows that by its return to the soil something is provided for the enrichment of future crops, although not all that was taken from it.

Comparative Values of Food. An animal which is productive, as the cow in milk or in calf, or the steer in process of fattening, utilises more of the valuable properties of food than an animal maintained in merely store condition, hence the manure produced by either is of less value, but in practice the productive animal is usually fed upon rich rations imported on to the farm, so that the manure produced may not only maintain the fertility of the soil, but actually increase it. Where no such food is imported, and where the livestock of the farm are fed solely upon its produce, the soil is gradually impoverished, especially as regards its most valuable constituent, nitrogen. Soil exhaustion, however, may be largely prevented in most cases by deeper and more thorough cultivation. The minerals below, when stirred, are submitted to the influence of air, and the insoluble foods they contain are gradually rendered available.

By the application of nitrogen in some artificial form to soil well supplied with potash, phosphoric acid, and lime, crops may be grown without exhausting it, but no farm practice is generally justified or economical where the employment of dung is ignored. As a soil is infertile where either nitrogen, potash, or phosphoric acid are absent, it follows that care must be taken that it is supplied with each, and in sufficient abundance. The systematic use of dung ensures this; but again, in practice where dung is the product of ill-fed stock, it must be supplemented by artificials containing one or more of these materials if the results are to be successful.

Value of Dung. Still, further, as dung possesses a mechanical value which artificial fertilisers do not, it is essential on both heavy and light soils owing to the importance of improving their texture. Vegetable and animal matter of all kinds contain some fertilising property, hence the compost heap of the gardener and the dung heap of the farmer. Even weeds are convertible into useful manure, but their life must first be destroyed, or the soil may be again infected by their presence, or by the germination of their seeds.

THE COMPOSITION OF MANURE: ANALYSIS OF ITS PROPERTIES.

[The figures given are per cent.]

	Water	Organic Matter	Nitrogen	Phosphoric Acid	Potash	Lime
Farm manure, mixed and fresh	75	21	·40	·18	·45	·49
Do. do. and rotten	75	19	·50	·26	·63	·70
Urine: Cow	92	6	0·8	0·70	0·60	0·07
Horse	89	8	1·2	1·20	0·90	0·04
Pig	97	1½	0·3	1·25	0·08	0·02
Sheep	86	10	1·4	0·50	0·60	0·30

Where dung is built into a heap, the sides should be perpendicular and compact, and the dung from each class of stock thoroughly mixed. As dung ferments or oxidizes, oxygen uniting with certain of its constituents in the presence of air, it should be kept as compact and cool as possible. In the uncovered farmyard, which is usually littered with straw, the manure is subjected to rain and fermentation prevented, but such practice is followed by great reduction in its value, owing to the washing away of a large proportion of its most valuable properties, while the labour of cartage to the land is increased.

Liquid Manure. Unless manure, the urine being absorbed by the litter, whether straw or peat moss, is daily carted to the fields, it should be heaped under cover, and above a tank intended for the salvage of the liquid. If a pump is erected above the tank, and in the centre of the heap, the liquid may be daily distributed over the solid manure, and while being absorbed, thus keep the heap cool. As we shall see later, the liquid excreta, weight for weight, is of greater value than the solid excreta of stock, although it is extensively wasted in farm practice. If this liquid, *i.e.*, urine, is drained into a tank, as already suggested, it must be diluted with about twice its volume of water in order to prevent the loss of its nitrogen, which will otherwise escape in the form of carbonate of ammonia. It follows that, from what has been said, a dung heap should be covered with a simple roof to prevent its damage by rain. Where a manure heap heats—and heating is more rapid in the case of the excreta of the horse than of the heavier excreta of cattle and pigs—nitrogen in the form of ammonia is quickly lost, while if washed by rain, the drainings will remove a large proportion of the two chief mineral fertilisers, potash and phosphoric acid. The loss of nitrogen may be prevented by the employment of gypsum (plaster of Paris) or the potassic fertiliser kainite, or even by the liberal distribution of dry earth.

Effect of Covered Yards. In farm practice of the best kind cattle and pigs are largely kept, as, indeed, are sheep in France, in covered yards or sheds, with the result that less straw is employed as litter, and the manure produced is not damaged by rain. Upon the condition of farming manure much depends. In rotten or fermented dung fertilising materials are more readily available to plants, although largely diminished in weight, this loss being due to oxidation and consequently to combustion. Fermented dung, however, is mechanically more useful than fresh or light dung containing abundance of straw, for the lighter soils, which it renders more compact, a remark which equally applies to heavy cow and pig dung; moreover, as these soils are not retentive, some of the fertilising constituents of raw or unfermented dung are quickly washed into the subsoil or the drains before they have been taken up by plants. On the other hand, unfermented dung, in which the litter is whole, improves the texture of the heavier soils, which it heats as it decomposes, while its fertilising properties are not wasted owing to the retentive power of soils of this character. Bearing these remarks in mind, it should nevertheless be understood by the student of farming that, while there is always loss as between the production of dung, solid and liquid, by stock, and its being covered by the plough, the loss is immensely smaller where it is taken into the field in quite fresh condition, the urine being absorbed by the solids and the litter, and still further that the results are inferior where the solid manure is used without the liquid.

There are many opinions as to the quantity of manure produced by animals. Much depends upon their weight, the food and water they consume, and, where litter is employed, upon the quantity supplied to them, but observations which have been made point to the production of from 8 to 10 tons, including litter under cover during the winter season of six to seven months.

Fertilising Materials. This may be estimated in the following way, it being first understood that the weight of the chief fertilising materials—nitrogen, phosphoric acid, and potash—present in a ton depends altogether upon the quality of the food consumed by the stock producing it, upon its condition, whether fresh or rotten, and the manner in which it has been preserved. Thus there may be from 9 to 15 lb. each of nitrogen and potash, and from 4 to 10 lb. of phosphoric acid. If, therefore, we take a sample containing 0·4 per cent. of nitrogen, 0·2 per cent of phosphoric acid, and 0·45 per cent. of potash, and value the nitrogen at 6*d.* a pound, the phosphoric acid at 2½*d.*, and the potash at 1½*d.*, we arrive at a total value of about 7*s.* 1*d.*

To this, however, something should be added to represent the value of the mechanical action of dung, which we believe has never yet been estimated; but if we place this as low as 2*s.* 6*d.*, we get a total of 9*s.* 7*d.*, which represents a ton of farm manure of quite moderate quality, although it is commonly sold by villagers and others to farmers at as little as 5*s.* A first-rate sample of dung valued in the same way would be worth some shiliings more; hence our desire to impress upon the reader the immense importance of care in the management of what, after all, is one of the most valuable properties of the farm. In daily practice a student will find that this value is largely ignored, that dung on the majority of homesteads is exposed to the rain, and consequently to partial destruction.

To be continued

Group 25
PHYSIOLOGY
3
Continued from page ...

THE ARCHITECTURE OF THE BODY

Various Tissues described. Chemical Composition of the Body. Repair and Decay. Uses of Food. How Temperature is regulated

By Dr. A. T. SCHOFIELD

The Tissues of the Body. We shall not here enter into a minute description of all the eight tissues, of which, as we have seen, the body is made up, because three of them, the *muscular, nervous, epithelial*, or *skin*, will be treated later. Of the remaining five, we shall examine the two most important, the *cartilaginous* and *bony*, first, and then briefly notice the *adipose*, or fat, the *fibrous*, and *connective* tissues.

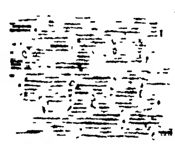
Cartilage forms the models of all the bones in the fœtus, or infant before birth (except the flat bones, which are made from thick membrane), and is the precursor of bone. It also persists through life in some parts to supply a smooth surface in joints to form tubes and to provide a yielding framework when required, as in the front of the chest. Cartilage is composed of cells, imbedded in a large amount of intercellular substance, that multiply by fission within the cell-wall, or capsule, which eventually forms the intercellular substance. It is generally covered with a membrane called *perichondrium*. It contains *no nerves*, and is of three varieties—*hyaline, white fibrous*, and *yellow elastic cartilage*.

Hyaline cartilage [16] has an intercellular substance or *matrix* like ground glass, which really consists of layers of *laminæ*, like those of an onion, round the cells. It contains no blood-vessels, and is principally found in joints, and in the ribs and nasal cartilages.

White fibrous cartilage has an intercellular substance or matrix of white fibres arranged in layers. It is found in a cartilage in the knee-joint, between the vertebra in the back, and in a few other places.

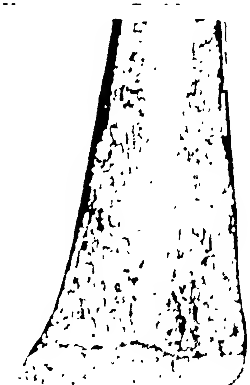
Yellow elastic cartilage has a matrix of yellow elastic fibres, and is found in the external ear, the epiglottis at the back of the tongue, and in the eustachian tubes, that lead from the throat to the ear [17].

Bones. Bones [18] form the framework of the body, and are hard, tough, and elastic. They are twice as strong as oak; one inch of compact bone will support 5000 lb. weight. They are a compound of two-thirds earthy material, principally phosphate of lime, and one-third animal, principally gelatine. They contain also a little carbonate and fluoride of lime, and phosphate of magnesium. These are so intimately blended that all the lime can be dissolved out by weak hydrochloric acid, and yet leave the bone the same shape, but flexible; or the gelatine can be removed by boiling with the same result as to shape, only the bone becomes brittle.



16. CARTILAGE CORPUSCLES

17. FROM A SECTION THROUGH THE EPIGLOTTIS
a. Perichondrium
b. Network of elastic fibrils surrounding the cartilage cells

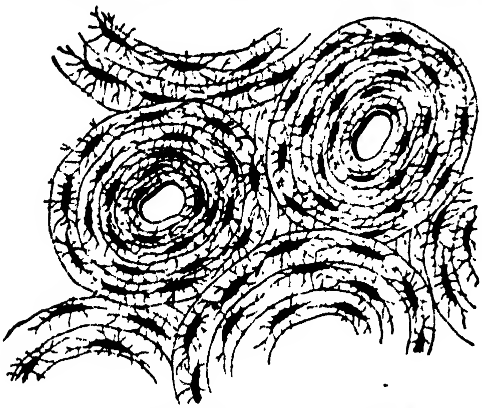


18. SECTION OF BONE
Natural size

The animal matter is in excess in the bones of the young, making them tougher; and the mineral in those of the old, making them more brittle. One cannot really break a baby's bones, which are like leather; whereas an old person's thigh-bone may snap right in two, from a fall on a carpet. Bone is of different qualities—*ivory*, or *dentine, compact tissue*, and *cancellous tissue*, or *spongy bone*. We get dentine in the teeth, compact bone in the shafts of the long bones, and cancellous tissue in their ends. Cancellous tissue is like pumice-stone, only the lattice work is beautifully arranged in regular Gothic arches, so as to support the greatest pressure with the smallest weight. One cubic inch, weighing a drachm, can support 500 lb. Flat bones have an exterior of compact tissue, and a layer of cancellous tissue inside.

Construction of Bone. Under the microscope [20] bone is found to consist of vertical bundles of scaly plates, with spaces between called *lacunæ*, connected together by tiny canals called *canaliculi*, $\frac{1}{20000}$ inch in diameter, and surrounding central ducts called *Haversian canals*, which branch and are connected with each other. In the lacunæ are large branched cells called *bone corpuscles*, the only really active living parts. They

never move, but spend their lives in nourishing the bone surrounding them. Round the bundles [19] of bony scales surrounding each Haversian canal



19. TRANSVERSE SECTION OF BONE
Showing laminæ, lacunæ, and canal

are other layers, binding, as it were, all together into the complete bone. These scales are all impregnated with lime salts. Bone is a substance formed out of cartilage in the following way: In the child before birth there is at first no bone, but models of every bone are formed in cartilage, which changes into osseous tissue. In the cartilage of the limbs, for instance, lime salts begin to form in the shaft, and at each end, until each of these three parts is changed into bone, the only cartilage left being a disc between the shaft and each end [21].

20. LONGITUDINAL SECTION OF BONE
a. Haversian or bone canals
b. Bone corpuscles

Let us notice the reason for this arrangement in the growing child and look at the difference between the shin-bone of a child and an adult [22]. While this bone is growing it is actively used all the time at the joints, as the child moves about. The part here must necessarily be hard, and the bone cannot therefore grow at the ends. It is consequently made in three pieces, and continues to grow just where the cartilage rings are till eighteen or twenty; then the cartilage disappears, and all three parts unite in one, and the length of the bone is finally fixed. Many bones are in *more* than three pieces in childhood. Take the bones of the spine, for instance [23]. Here we see that no fewer than six pieces are fused into one at manhood. This will explain how carefully a growing child should be handled, and how straight the spinal column should be kept, when it is built up of over 200 pieces instead of 26 solid bones.

Flat bones like the shoulder-blades and the bones of the skull are formed of tough membrane instead of cartilage, and in it the lime salts grow in the same way.

Shape and Size of Bones. Bones are hollow to make them lighter and stronger. In birds they are filled with warm air, which in the swift swallow enters even the small bones of the toes. The tubular construction, with its resultant strength, is common throughout nature. When Galileo, the great astronomer, was a prisoner in the Spanish Inquisition, accused of infidelity, he picked up a hollow straw from his dungeon floor and said, "If there were nothing else in Nature to show me the existence of a God, this would suffice." The interior of the bones in man is filled with *marrow*, except in the air-cells of the frontal bone and some bones of the face. *Red marrow* is found in cancellous tissue, and contains large numbers of lymph corpuscles and blood corpuscles. This marrow is probably one of the sources of the blood corpuscles. *Yellow marrow* (mostly fat) fills the shafts of long bones.

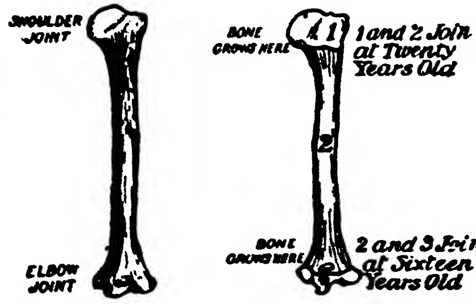
Bones are of many sizes and shapes, but may roughly be divided into four varieties:

1. LONG BONES. These are chiefly found in the limbs and ribs. They form long levers by which the arms and legs are moved. They consist of a middle part or shaft and ends or extremities, covered with cartilage, the bones themselves being covered with fibrous tissue, which forms a tough skin (*periosteum*) over them. The shaft is generally hollow, and contains the blood-vessels, and some fat called marrow.

2. SHORT BONES. These are found in the wrist and ankle, and wherever great strength is wanted in a joint.

3. FLAT BONES. These are like plates, flat or rounded, and are used to protect parts. They are formed of two hard outer layers, with light spongy tissue between. The skull and the shoulder-blades are made of flat bones.

4. IRREGULAR BONES. These include all



21. DIAGRAM OF ADULT AND GROWING BONE

the bones of no particular shape, such as the vertebræ of the backbone, and some others.

Other Kinds of Tissue. Adipose or fat tissue exists all over the body between the muscles and the skin, as a protective covering, and a retainer of heat, fat being, like the felt covering a boiler, a non-conductor of heat. It is also used internally as packing round various organs. It is formed of loose fibrous tissue full of cells, containing globules of oil. No tissue in the body varies so much in quantity at different times.

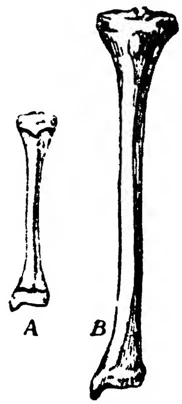
Fibrous tissue is made up of strong fibres with a few cells, and forms the tendons and ligaments, and all the strong bands of the body; whether attached to muscles, surrounding joints, or binding the various bones together [24].

Connective tissue is absolutely everywhere, and connects all the other structures and tissues together by masses of loose fibres with scattered cells.

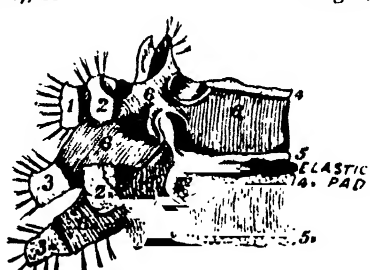
As the intercellular substance is the cement between cells that form each tissue (cartilage, bone, etc.), so the connective tissue is the mortar for the whole body, that forms all the structures and tissues into a solid building.

Chemical Construction of the Body. Let us emphasise, even at the risk of going over old ground, the great fact that life consists of *Metabolism*, in other words of *incessant change*; and trace roughly the process by which the change is effected. Then we shall *analyse the body* and resolve it into its several constituents, noticing the remarkable fact that the food of the body, which is considered in its proper place in the section on HEALTH, exactly corresponds with the analysis of the materials of the body, showing thereby how entirely it meets its needs.

We shall then discuss the means by which the *body heat* is manufactured and maintained; and so grasp the fact of the enormous force required to warm a man of some 150 lb. weight to a constant heat of nearly 100° F., whatever the external temperature may be: a force that runs to nearly 3000 foot-tons (or tons raised a foot high) per day. Lastly, we shall consider the daily *gain and loss of the body*, and thus be prepared to commence the study of Physiology proper, to which these first two sections form an introduction, and which consists of a detailed description of the vital processes of the various systems of the body.

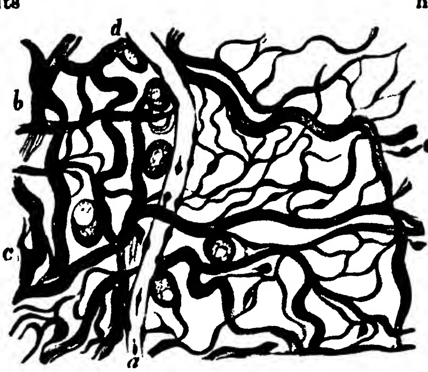


22.
a. CHILD'S TIBIA
b. ADULT'S TIBIA



23. DIAGRAM OF TWO VERTEBRÆ FROM THE MIDDLE OF A CHILD'S SPINE

They are separated by an elastic pad, and each is in six parts; the upper and lower plates being formed of soft cartilage. After twenty-five each vertebra is one solid bone



24. PLEXUS OF BUNDLES OF FIBROUS TISSUE FROM THE OMENTUM OF RAT

a. A capillary blood-vessel. *b.* Bundles of fibrous tissue. *c* The connective tissue corpuscles. *d.* Plasma cells

Repair and Decay. Let us then glance first at the great question of METABOLISM. Life has been shown to be a condition of incessant change, dependent on the two opposite principles of *repair* and *decay*.

One twenty-fourth part of the body (more or less) wastes every day, and this has to be made good. To effect this, we have to take in fresh material at the rate of about *a ton a year*. Life has been happily said to be a condition of *dynamic equilibrium*, never absolutely balanced, however, but ever oscillating to one side or the other. We are never exactly the same weight for two minutes together.

If a person could be placed upon a scale, accurately balanced with his weight, at 6 a.m., and carry on his day's routine in that position he would find while lying in bed the scale was very slowly rising, as he got very gradually lighter, from the slow wasting of the tissues. When he began to dress he would find himself ascending in the air more quickly, presuming, of course, that his clothes are not weighed, the destruction of the body being much more rapid with any exertion. At breakfast the scale would suddenly descend from the food taken, to far below its level at 6 a.m. Then, till lunch, if in active business with brain or manual work, he would rise steadily from the loss of weight. At lunch the descending movement would be repeated, and thus the daily round would go on.

The whole of these changes that take place in the living body are included in the one word, *Metabolism*; which includes not only the wear and tear of life, the destruction or *Katabolism*, and repair or *Anabolism*, of all living tissue, but also the processes producing the manifestation of living force and energy necessary to its storage and expenditure. Animal force and energy are

evolved by the reduction of *complex* substances to *simple*.

A complex substance, such as meat, is built up of large numbers of molecules like a tower of bricks. Of course, force or energy has been required to do this. As this substance is reduced to simple bodies, containing fewer molecules, such as *urea*, *carbonic acid*, and *water*, the force stored up in the meat as *potential* energy becomes manifested and used as *kinetic* energy, or active life force.

Life a Twofold Process. The whole process of life is, therefore, twofold; the one consisting in the reception, assimilation, metabolism, and excretion of matter, or the *vegetative function*; the other in the *animal functions*, or the direction of the energy thus set free by means of the will, nerves, and muscles to the purposes of life.

Food is, therefore, required for two great purposes: (1) to repair the tissues of the body, and (2) to be stored as potential force for future use. In regard to food, we have to consider both quality and quantity. It must be suitable and it must be sufficient. To be suitable for repair, it must be homologous, *i.e.* of the same nature as that which has to be made good. If of a different nature it is heterologous, and is a poison or medicine, not a food. We will, therefore proceed first to examine the composition of the human body.

The Composition of the Human Body. The human body contains one fourth of all the known elements (17 out of 67). Chief among them in importance and quantity are the four non-metallic elements: *oxygen*, *carbon*, *hydrogen*, and *nitrogen*; and the three metals, *calcium*, *sodium*, and *potassium*. The following is a rough analysis of the body:

Oxygen [O]	72·0
Carbon [C]	13·5
Hydrogen [H]	9·0
Nitrogen [N]	2·5
Calcium [Ca]	1·3
Phosphorus [P] and Sulphur [S]	1·2
Sodium [Na], Potassium [K], Chlorine [Cl], Iron [Fe], Magnesium [Mg], Silicon [Si]. Traces only of Lead [Pb], Copper [Cu], and Aluminium [Al]	·5
	100·0

It will thus be seen that the metals form less than 2 per cent. of the whole body.

In round numbers we may say the body is $\frac{3}{4}$ O, $\frac{1}{8}$ C, $\frac{1}{10}$ H, $\frac{1}{40}$ N. Its average weight is 150 lb., of which 113 lb. are water, and 37 lb. solids, made up as follows: Muscles, 17 lb.; fat, 6 lb.; food in blood, 4 lb.; bones, 10 lb.

A more graphic way of considering the composition of the body is to compare its contents and their quantities to well-known articles of food, or commerce. This has been done in many ways. For instance, it is computed that a woman's body is equal in composition and amount to 1000 eggs.

She is composed of gases, liquids, and solids. Of oxygen there is enough to fill 200 36-gallon barrels; of nitrogen 4½ lb.; of hydrogen, enough to fill a balloon capable of lifting the woman over 2000 feet; of carbon 21½ lb., or enough to make 9000 lead pencils; of iron there are 48 grains, enough to make five tacks; of salt enough to fill six saltcellars; of phosphorus, 3½ lb., enough to make 8000 boxes of matches; of water there is enough to fill a 9 gallon barrel.

Substances of the Body. Leaving these fantastic ideas, we must remember that the various substances of the body do not occur often as elements, but chiefly as compounds, which are generally of great complexity. The following are the chief of these:

1. INORGANIC LIQUIDS. WATER. This forms two-thirds by weight of the whole body. The fluids of the body contain from 80 to 99 per cent. The solids vary from the enamel with 2 per cent. to the kidneys with 82 per cent. Skin, hair, muscle, are all three-fourths water; bone and cartilage, one-half; and fat about a quarter.

ACID. Hydrochloric in the gastric juice.

2. INORGANIC GASES. These include chiefly O, H N, and CO_2.

OXYGEN [O]. This gas is essential to all vegetable and animal life. It is the only element directly used in the body—to the extent of 7000 grains daily, which represents also, of course, the daily loss.

HYDROGEN [H]. This gas, by its combination in the body with O, forms water. It also enters into nearly every organic compound.

NITROGEN [N]. This gas is found in the body in its free state, merely as a diluent of oxygen; though in combination it is an integral part of every tissue. The daily quantity lost by the body is 300 grains.

CARBONIC DIOXIDE, or CARBONIC ACID GAS [CO_2]. This is formed in the body by the combination of O with carbon.

CARBON itself is also a most important part of organic compounds; 5000 grains a day are used, and it enters into nearly every part of the body.

3. INORGANIC SOLIDS. SALTS. Chiefly chlorides of sodium, and potassium, and phosphates of calcium, and sodium. Sodium chloride (common salt) is the most important of these. It occurs everywhere, and is absolutely necessary for existence.

CALCIUM PHOSPHATE is the most abundant salt, and forms half of the bones.

Organic Bodies. These may be divided into two great classes, *nitrogenous* and *non-nitrogenous*. The first consists mainly of albumen (proteid), the latter of starches, sugars, and fats.

1. NITROGENOUS COMPOUNDS. These all contain C, O, H, N, and S (sulphur). They include *albumen* of all sorts (like the white of egg) found in all cells, forming the bases of protoplasm; in the blood and lymph, in muscle and nerve, in cartilage and bone, and in the skin.

SECRETIONS. These include the constituents of bile (glycocholic and taurocholic acids), bile pigments, and all the ferments, and digestive fluids of the body that contain nitrogen.

Excretions. These are the effete products of the body, and include urea. uric acid, leucin, tyrosin, etc., passed by kidneys and bowels.

2. NON-NITROGENOUS COMPOUNDS. These are divided into the two great classes of *Carbohydrates* and fats and oils, or *Hydrocarbons*.

Carbohydrates. These bodies all contain carbon, also hydrogen and oxygen in the proportion to form water, and include animal starches, such as *glycogen* in the liver and *dextrin* in muscle; also *sugars* found in the liver, blood, muscles, etc.

Hydrocarbons, or fats and oils. These contain carbon, and hydrogen and oxygen, but not in the proportion to form water. They are found in all body fat, in bile, etc.

A close comparison of this list of the constituents of the body with that of foodstuffs in the section on Health will show how surprisingly they resemble each other. The food taken is exactly adapted in detail to the waste of the body, and that so largely by instinct, that few have any idea why certain articles are food and others are not, and why they are eaten in certain proportions. A comparison of these two sections will give the key.

The Heat of the Body. The heat of the body is maintained by chemical reactions; mainly by the combustion of O with the production of CO_2 and water. It is a form of energy, and is produced by the vibration of the molecules. The ultimate source of it is the food, and oxygen taken into the body; and the cause of it is the metabolism or vital changes of the body. The amount of it depends upon the amount of these changes. The repair, building up, or *anabolism* of the tissue is, however, believed rather to absorb heat than to evolve it. It is in the decay, oxidation, or *katabolism* of the tissue that heat is principally evolved. It is found, indeed, by direct experiments that the amount of C and H that unite in the body in twenty-four hours with O is sufficient to maintain the body temperature for a day. The energy stored in the food of the body could be truly described as latent heat, were all of it used in the production of heat. Nevertheless, though some of it produces mechanical and electrical energy, it is convenient to measure its potential forces under the head of *heat units*.

Heat Units. A heat unit is the force that raises one pound of water 1° F., and corresponds in mechanical energy with 772 work units (a work unit being 1 lb. raised one foot high). In other words, it requires 772 times as much force to raise 1 lb. water 1° F. as it does to raise 1 lb. one foot high. The amount of heat units in any food is found by burning it in a closed chamber, surrounded with a fixed quantity of water; which in its turn is in a chamber, isolated by non-conducting substances and cold water, from any external heat. The heat evolved passes by means of a coiled lead tube through the water, and the increase of its temperature, ascertained by delicate thermometers, multiplied by the volume of water, readily gives the number of heat units. A living animal can be placed inside the chamber instead of food, and the heat it gives off, passed through the water in like manner, shows the number of heat units it evolves.

It is thus found that 52 parts of fat contain as many heat units as 100 of albumen, or proteid, 114 of starch, or 130 of sugar. The reason that fat gives so much more heat than starch or sugar, is, as I have said, that in the latter the H and O are in the proportions to form water, so that the C alone is burnt; whereas in fat there is always a great excess of H, so that both C and H oxidise, and are sources of heat. Some heat, no doubt, enters the body through hot drinks.

The places where most heat is produced are the muscles, the secreting glands and organs and the brain. The muscles form about one half of the body, and the bones nearly the other half. The latter produce but little heat, whereas the former are the greatest *thermogenic* (*i.e.* heat-producing) centres in the body. Muscle-work forms about one-fifth of all the work done in the body, and nine-tenths of it is produced in the form of heat units, and only one-tenth in mechanical energy. The heart must be included with the muscles as a thermogenic centre.

The secreting glands, such as the liver, produce heat. With salivary glands, the blood leaving them is a degree hotter when they act than when they are passive. In the liver of the dog the temperature is often 105°.

The brain, by its active *metabolism*, is also a source of heat.

Other small sources of heat are the concussion of joints, the friction of muscles, blood, the formation of salts, and other chemical changes.

Warm and Cold-blooded Animals. Warm and cold-blooded animals have lately been called *homoiothermal*, or of uniform heat, and *poikilothermal*, or of varying heat; because the real difference between them is that the blood in a warm-blooded animal remains the same, notwithstanding variations in surrounding temperature; while the blood in the cold-blooded animal varies with the surrounding medium.

Of warm-blooded animals (mammals and birds), man has a temperature of 99° F. (98·6 in the armpit); the average temperature of the mammalia being 101° F. In birds the average temperature is 107° F. Amongst cold-blooded animals many vary but slightly with the surrounding temperature. Snakes average 82° F.; in cold weather they are hotter, and in hot, colder than the air. Fish are often one or two degrees warmer than the water. The frog is generally about half a degree warmer than the water.

In warm-blooded animals the metabolism and the consumption of oxygen increase in cold weather and decrease in hot; whereas in cold-blooded animals the metabolism and the consumption of oxygen decrease in cold weather and increase in hot.

This shows that there is some regulating centre that governs the production of heat. That this centre is *nervous* is shown by the fact that after poisoning with curari—a nerve poison—this regulating power is lost, and the

warm-blooded animal behaves like a cold-blooded one. Though the blood can complete the circuit of the body in twenty-three seconds, the temperature varies as follows:

On the skin from 72·6 F. at the tip of nose and ear to 98·6° F. in closed axilla; the average being about 92 to 94° F. The skin is observed to be warmer over muscles than over bone.

In the rectum the temperature is 100°. In the blood it is 102° F., in the brain 104° F., in the liver and heart 106° F.

Muscles and glands increase in heat one degree during action, and the brain about half a degree.

Conditions Governing Heat. The principal conditions affecting the mean temperature of the body are age, sex, period of day, exercise, season, food, poisons and disease.

AGE. In the newly-born the temperature is one degree above normal, also in the very aged; but in these, the governing centres being feeble, exposure soon lowers it to a dangerous degree.

Infants and children are much subject to feverish attacks, owing to the activity of their metabolism, and the imperfect development of the regulating centre. From 28 to 65, this centre being fully developed, the temperature of the body is kept more uniform; while in old age variation from slight causes again occurs readily.

SEX. In woman the temperature is higher than in man.

PERIOD. The temperature rises during the day and falls during the night, being highest at 6 p.m. (99·8° F.) and lowest at 2 a.m. (97·6° F.), at which hour most deaths occur.

EXERCISE. Active exercise will increase the temperature from one degree to two degrees Fahrenheit.

SEASON. In summer the temperature sometimes temporarily rises to three degrees higher than in winter. Climates varying 100° F. have no permanent effect on body temperature.

FOOD. There is a very slight rise after food; a fall of one degree after taking cold alcohol; and a temporary rise of five degrees after taking hot alcohol, with a subsequent fall.

POISONS. Alcohol, quinine, aconite, etc., decrease temperature; strychnine raises it.

DISEASES. In diseases the temperature varies from 77° F. in Asiatic cholera to 107° F. in pneumonia. After death the temperature rises for a short time, especially at the onset of *rigor mortis*.

Nature's Economy. The heat of the body may be regulated by altering the amount lost or produced. In the body this is done in various ways, the process being governed by a nervous centre. Body heat is *diminished* by the skin, lungs, urine, cold food, cold alcohol, and air. By the skin about 75 per cent. is lost; by the lungs 20 per cent.; by urine, etc., 3 per cent.; and about 2 per cent. in other ways.

Heat is lost from the skin by *conduction*, *radiation*, and *evaporation*. Besides the central regulating power, the skin has a power by reflex action. A hot atmosphere acts on the sensory nerves, and by the vaso-motor nerves *dilates* the surface capillaries and reduces the heat by evaporation. A cold atmosphere, on the other hand, *closes* the capillaries and retains the heat in the body. Thus external heat and cold, through the wondrous economy of Nature, defeat their own ends.

There appears to be in the action of the skin a balance between *radiation* and *evaporation* that tends to assimilate the loss in winter and summer. In cold weather much heat is lost by radiation, little by evaporation, the capillaries being contracted. In hot weather much is lost by evaporation and little by radiation, the temperature being so high.

The loss of heat from the skin can be largely regulated by clothing; wool, being a bad conductor, is obviously the best covering for the skin. A naked man is said to be unable to maintain his normal heat when the temperature is below 81° F.

The loss of heat by the lungs is fairly constant, as, unlike the skin, they have no power of reflex action. The loss does not, moreover, vary with the surrounding temperature, and but little with exercise.

Regulation of Heat-production. The production of heat can be regulated by *food*, *exercise*, and *nervous influence*. Amongst foods, fat, as we have seen, gives the most heat. In paralysis, the affected part loses heat. In nervous excitement heat is increased, in nervous depression it is diminished. In exercise the increased heat is largely counterbalanced by the increased loss. The shivering from cold helps to warm the body. It is calculated that a man produces nearly two heat units per minute; that is a force able to lift nearly three-quarters of a ton one foot high. I have already spoken of a heat-governing centre. This probably controls the heat-producing and heat-losing centres. Nothing is known of the details of the action of these centres. Great extremes of dry heat can be borne for a short time owing to the power of evaporation possessed by the skin; thus 260° has been borne for eight minutes, while Chabot, the fire king, entered an oven at 500° F. At the same time, if the heat is moist evaporation is prevented, the air being already saturated, and 112° F. cannot be endured.

Death from too great heat appears to arise from too rapid and exhaustive metabolism; that from cold from too slow and diminished metabolism; death in the latter coming with torpor and sleep.

The Balance-sheet of the Body. Now turn to consider the interesting question of the daily GAIN AND LOSS of the body; in other words, to present its balance-sheet.

The body loses daily 2¼ lb. of solids and gases and 6 lb. of water.

This loss is made up as follows:

The lungs contribute 5,000 grains of H_2O and 15,000 of CO_2. The skin contributes 11,500 H_2O and 250 of solids and gases. The kidneys contribute 23,000 H_2O, and 1,100 solids. The intestines contribute 2,000 H_2O and 800 solids.

The body receives daily nearly 1¼ lb. (8,000 grains) dry food, 5½ lb. water (as liquid or combined with food), and 1¾ lb. of oxygen gas.

It will be observed that half a pound less

water is taken in daily than is given out. The difference is made up by combustion in the body. Nearly the same amount of nitrogen that is taken in is excreted as urea.

This daily amount of gain and loss may be regarded as income and expenditure; while the weight of the body partly represents the capital.

Observe that the body receives a *solid* (food), a *liquid* (water), and a *gas* (oxygen). It excretes a *solid* (urea and excreta) by intestines and kidneys, a *liquid* (water) by intestines and kidneys, a *liquid* (water) by kidneys and skin, and a *gas* (carbonic acid) by the lungs.

The amount of food taken represents about 3400 foot-tons (tons raised one foot high) of force, and of this nine-tenths, or 3060 foot-tons (a force equal to lifting a man 8¼ miles high), are used in maintaining the heat of the body, and the remaining 340 foot-tons in the active functions of life, whether in storing force by its physiological processes or spending it by its nervous or mechanical energy.

Now let us consider the chemical analysis of the 8½ lb. that are lost daily. This amount may be divided into 1 lb. solid, 1½ lb. gas, and 6 lb. water. The water and gas need no analysis. The solids contain 4500 grains of C, 300 grains of N, or the general proportion of 15 parts of C to 1 of N. The quantities of hydrogen and oxygen in the solids are of no moment, as they can be supplied by air and water to any amount free of all cost.

If these two elements, C and N, could, therefore, in their uncombined state, be used as food, the problem of diet would be solved; but, unfortunately, animals cannot feed on C or N as elements, and we have, therefore, to find that food that will supply the right quantity of these elements with the least waste. This problem is solved in the section on HEALTH.

The Body a Steam Engine. It may be profitable in various ways to compare the vital action of the body with a steam engine.

Three pounds of coal, costing one penny, will, properly burnt, raise one ton half a mile high and boil 22 quarts of water.

Three pounds of food, costing one shilling, will raise one ton half a mile high, or carry the body, with a weight of 85 lb. on it, 20 miles in seven hours, besides warming and repairing the body. Or,

Three pounds of food, costing one shilling, will repair the body, boil 22 quarts of water, and raise one ton half a mile high.

The outcome of all this is that the body is about twelve times as expensive to work as a locomotive. Of course, food varies in the amount of force it gives out. Theoretically, 100 lb. of fat gives the same force as 213 of proteids, or 202 of starch or sugar.

We must remember, moreover, that for every foot-ton (one ton raised one foot) done in mechanical work (motion, locomotion, etc.), nine foot-tons are used in maintaining the body heat, and other processes.

The amount of air food required varies, of course, enormously. For instance, in a state of rest 480 cubic inches of air are breathed per minute; if walking three miles an hour, 1550; if running six miles an hour, 3260. So delicate is the automatic supply of air food, that there is a difference in the rate of respiration between travelling third and first class, and between sitting up and lying down.

The average man requires, to replace the waste of the body, 307 grains of nitrogen and 4700 of carbon daily, besides oxygen and hydrogen (unlimited)—*i.e.* about the same that we have seen is lost. The following are actual amounts used daily in four different sorts of work:

	Nitrogen Grains	Carbon Grains
London needlewoman ..	135 ..	3270
„ navvy	350 ..	6200
Prisoner, light work ..	226 ..	4356
„ hard labour ..	263 ..	5013

Weston, the pedestrian, used 545 grains of nitrogen and 7880 of carbon to produce 790 mechanical foot-tons of force which he spent in walking 50 miles a day.

NOTE. On page 96 the figure 96¼ on fourth line from bottom of the right-hand column should be 98¼. In the Short Dictionary of Physiological Terms on page 102 (which was compiled independently of Dr. Schofield's course) the word "inner" in the definition of *Fibula* should be "outer."

To be continued

Group 18

LANGUAGES

3

Continued from page [illegible]

LATIN. ENGLISH. FRENCH.

Latin and English by Gerald K. Hibbert, M.A. French by Louis Barbé, B.A., French Master at the Glasgow Academy

LATIN

Continued from page [illegible]

By Gerald K. Hibbert, M.A.

Section I. GRAMMAR.

Nouns: Third Declension. The Third Declension has two divisions: (*a*) Consonant stems; (*b*) -*i* stems.

Roughly speaking, the nouns in the first division have more syllables in their genitive singular than in the nominative singular (Imparisyllabic), while those in the second have the same number of syllables in the genitive singular as in the nominative singular (Parisyllabic).

Consonant Stems: Masculine and Feminine.

Singular.

	Judge, m.	*Man*, m.	*Age*, f.	*Lion*, m.	*Foot*, m.	
N.V.	judex	homo	aetas	leo	pes	—
Acc.	judic-	homin-	aetat-	leon-	ped-	EM
Gen.	judic-	homin-	aetat-	leon-	ped-	IS
Dat.	judic-	homin-	aetat-	leon-	ped-	I
Abl.	judic-	homin-	aetat-	leon-	ped-	E

Plural.

N.V.A.	judic-	homin-	aetat-	leon-	ped-	ES
Gen.	judic-	homin-	aetat-	leon-	ped-	UM
D. Abl.	judic-	homin-	aetat-	leon-	ped-	IBUS

Singular.

	Father, m.	*Law*, f.	*Honour*, m.	*Cinder*, m.	*Swine*, com.	
N. V.	pater	lex	honos	cinis	sus	—
Acc.	patr-	leg-	honor-	ciner-	su-	EM
Gen.	patr-	leg-	honor-	ciner-	su-	IS
Dat.	patr-	leg-	honor-	ciner-	su-	I
Abl.	patr-	leg-	honor-	ciner-	su-	E

Plural.

N.V.A.	patr-	leg-	honor-	ciner-	su-	ES
Gen.	patr-	leg-	honor-	ciner-	su-	UM
D. Abl.	patr-	leg-	honor-	ciner-	su-	IBUS

Consonant Stems: Neuter.

Singular.

	Grass.	*Work.*	*Time.*	*Hard wood.*	
N. V. A.	gramen	opus	tempus	robur	—
Gen.	gramin-	oper-	tempor-	robor-	IS
Dat.	gramin-	oper-	tempor-	robor-	I
Abl.	gramin-	oper-	tempor-	robor-	E

Plural.

N. V. A.	gramin-	oper-	tempor-	robor-	A
Gen.	gramin-	oper-	tempor-	robor-	UM
D. Abl.	gramin-	oper-	tempor-	robor-	IBUS

Similarly with other neuter nouns: *caput, capitis* (head); *crus, cruris* (leg); *fulgur, fulguris* (lightning); *cadaver, cadaveris* (corpse), etc.

-*i* Stems.

Singular.

	Raft, f.	*Temple*, f.	*Art*, f.	*Tooth*, m.	*Shower*, m.
N. V.	ratis	aedes	ars	dens	imber
Acc.	ratem	aedem	artem	dentem	imbrem
Gen.	ratis	aedis	artis	den is	imbris
Dat.	rati	aedi	arti	den i	imbri
Abl.	rate	aede	arte	dente	imbre

Plural.

N.V.A.	rates	aedes	artes	dentes	imbres
Gen.	ratium	aedium	artium	dentium	imbrium
D. Abl.	ratibus	aedibus	artibus	dentibus	imbribus

(Note the -*i* in the genitive plural.)

Singular.

	Fire, m.	*Animal*, n.	*Bone*, n.	*Sea*, n.
N. V.	ignis	animal	os	mare
Acc.	ignem	animal	os	mare
Gen.	ignis	animalis	ossis	maris
Dat.	igni	animali	ossi	mari
Abl.	igne *or* i	animali	osse	mari

Plural.

N. V. A.	ignes	animalia	ossa	maria
Gen.	ignium	animalium	ossium	marium
D. Abl.	ignibus	animalibus	ossibus	maribus

Note. -*i* nouns in -*ans* and -*ens* often drop -*i* in genitive plural, *e.g. parens, parentum.* The accusative plural of -*i* nouns (mas. and fem.) is often spelt as ending in -*is*, *e.g. dentis* for *dentes*.

Adjectives: Third Declension. All adjectives, except those in -*us*, -*a*, -*um*; and in -*er*, -*a*, -*um*, follow the third declension. Thus, melior (*better*), similis (*like*), ingens (*vast*), audax (*bold*).

Singular.

	M. F.	*N.*	*M. F.*	*N.*
N V.	melior	melius	similis	simile
Acc.	meliorem	melius	similem	simile
Gen.	melioris		similis	
Dat.	meliori		simili	
Abl.	meliore *or* i		simili	

Plural.

N. V. A.	meliores	meliora	similes	similia
Gen.	meliorum		similium	
D. Abl.	melioribus		similibus	

Note. All adjectives ending in -*is* make their ablative singular in -*i*.

Singular.

	M. F.	*N.*	*M. F.*	*N.*
N. V.	ingens		audax	
Acc.	ingentem	ingens	audacem	audax
Gen.	ingentis		audacis	
Dat.	ingenti		audaci	
Abl.	ingente *or* i		audaci (rarely *e*)	

Plural.

	M. F.	N.	M. F.	N.
N. V. A.	ingentes	ingentia	audaces	audacia
Gen.	ingentium		audacium	
D. Abl.	ingentibus		audacibus	

N.B. Decline all present participles like *ingens*.

Adjectives in *-er* of the third declension have three endings in nominative singular: *e.g.* celer, celeris, celere (*swift*); acer, acris, acre (*keen*). No other adjective is declined like *celer*.

Singular.

	M.	F.	N.	M.	F.	N.
N. V.	celer	celeris	celere	acer	acris	acre
Acc.	celerem		celere	acrem		acre
Gen.	celeris			acris		
D. Abl.	celeri			acri		

Plural.

	M. F.	N.	M. F.	N.
N. V. A.	celeres	celeria	acres	acria
Gen.	celerium		acrium	
D. Abl.	celeribus		acribus	

Comparison of Adjectives. The adjective has three degrees of comparison: the positive, the comparative, and the superlative, *e.g.*, *longus*, long; *longior*, longer *or* too long; *longissimus*, longest *or* very long.

The comparative is formed by changing the *-i* or *-is* of the genitive of the positive into *-ior*; and the superlative into *-issimus*. Thus:

durus (*hard*)	gen. *duri*	durior	durissimus
tristis (*sad*)	gen. *tristis*	tristior	tristissimus
audax (*bold*)	gen. *audacis*	audacior	audacissimus

EXCEPTIONS.

1. Adjectives in *-er* form the superlative by adding *-rimus* to the nominative (*i.e.* they double the *-r* and add *-imus*). *e.g.*:

asper (*rough*) asperior asperrimus
(So celer, miser, liber, pauper, tener, etc.)
pulcher (*beautiful*) pulchrior pulcherrimus
(So niger, piger, acer, ruber, vafer, etc.)
vetus (*ancient*) has superlative veterrimus (no comparative).

2. Six adjectives in *-ilis* double the *-l* and add *-imus*:

similis (*like*) similior simillimus

So dissimilis (*unlike*), facilis (*easy*), difficilis (*difficult*), gracilis (*slender*), humilis (*lowly*).

All the others in *-ilis* are regular: thus
utilis (*useful*) utilior utilissimus

3. The following are irregular:

bonus (*good*)	melior	optimus
malus (*bad*)	pejor	pessimus
magnus (*great*)	major	maximus
parvus (*small*)	minor	minimus
multus (*much*)	*plus (neuter)	plurimus
nequam (*wicked*)	nequior	nequissimus
dives (*rich*)	divitior / ditior	divitissimus / ditissimus
senex (*old*)	senior	natu maximus (*by birth the greatest*)
juvenis (*young*)	junior	natu minimus
potis (*able*)	potior (*better*)	potissimus (*best*)
(no positive)	ocior (*swifter*)	ocissimus
frugi (*frugal*)	frugalior	frugalissimus
egens (*needy*)	egentior	egentissimus

* There is no masculine or feminine singular of *Plus*, but full plural: Nom. Acc. *plures, plura*: Gen. *plurium*: D. Abl. *pluribus*.

4. Adjectives in *-dicus*, *-ficus*, and *-volus* change *us* into *-entior*, *-entissimus*.

maledicus	maledicentior	maledicentissimus
beneficus	beneficentior	beneficentissimus
malevolus	malevolentior	malevolentissimus

5. Adjectives ending in *-us*, preceded by a vowel, have no comparative or superlative: to form one, use *magis* and *maxime* (adverbs) = more and most. Thus:

idoneus (*useful*) magis idoneus (*more useful*) maxime idoneus (*most useful*)

But *antiquus*, *pinguis*, and *tenuis* are regular, because the *-u* is really consonantal.

6. The following spring from prepositions:

citra (*on this side*)	citerior	citimus
de (*down from*)	deterior (*worse*)	deterrimus
extra (*outside*)	exterior	extremus / extimus
infra (*below*)	inferior	infimus / imus
intra (*within*)	interior	intimus
post (*after*)	posterior (*later*)	postremus (*last*) / postumus (*last-born*)
prae (*before*)	prior	primus (*first*)
prope (*near*)	propior	proximus
super (*above*)	superior	supremus (*last* or *highest*) / summus
ultra (*beyond*)	ulterior	ultimus (*last*)

Adverbs: Comparison. Adverbs derived from adjectives with *-i* stems usually end in *-ter*; from other adjectives, usually in *-e*. Thus: audax (*bold*), audacter (*boldly*); brevis (*short*), breviter (*shortly*); dignus (*worthy*), digne (*worthily*).

In comparison they imitate their corresponding adjective, but make comparative *-us*, superlative *-e*:

graviter (*weightily*)	gravius	gravissime
digne	dignius	dignissime
audacter	audacius	audacissime

So: saepe (*often*) saepius saepissime
diu (*long*) diutius diutissime

Irregular:

multum (*much*)	plus	plurimum
magnopere (*greatly*)	magis (*most*)	maxime

Pronouns: Relative.

Qui, who or which.

	Singular. M.	F.	N.	*Plural.* M.	F.	N.
N.	qui	quae	quod	qui	quae	quae
A.	quem	quam	quod	quos	quas	quae
G.	cujus			quorum	quarum	quorum
D.	cui			quibus *or* quis		
A.	quo	qua	quo	quibus *or* quis		

Interrogative. *Quis, who or what? (only in questions).*

Declined like qui, except the nominative and accusative singular:

	M.	F.	N.	
Nom.	quis	(quis)	quid	*
	qui	quae	quod	
Acc.	quem	quam	quid	*
	quem	quam	quod	

Also the *Indefinite* pronoun *quis* (anyone) is declined like the interrogative, except that the nominative singular is *quis, qua, quid.*

Compounds of *qui* and *quis:*

1. *Quisnam, quidnam?* (also *quinam*) = who?
2. *Ecquis, ecqua, ecquid?* = anyone? (rare).
3. *Aliquis, aliqua, aliquid* = someone.
4. *Quispiam, quaepiam, quodpiam* = some.
5. *Quisquam, quicquam* = any at all (generally used with negatives, *e.g. nec quisquam* = nor anyone, *i.e.* "and no one").
6. *Quidam, quaedam, quiddam* = certain, a certain person (very definite).
7. *Quicumque, quaecumque,* etc. = whosoever.
8. *Quisquis* = whosoever; *quidquid* = whatsoever.
9. *Quivis, quaevis, quodvis* = which you will (very indefinite: *vis* means "thou wishest," from *volo* = I wish).
10. *Quilibet* = which you like (*libet* is an impersonal verb = it pleases).
11. *Quisque, quaeque, quicque* = each (also *unusquisque* = each one).

Section II. SYNTAX.

Rule 1. The relative agrees with its antecedent (*i.e.* the word to which it *relates*) in number, gender, and person, but takes its case from its own clause: *e.g., Carus est amicus quem cras videbo* = dear is the friend whom I shall see to-morrow.

Rule 2. "Than" after a comparative is expressed by "*quam.*" But if the comparison is being made between two *nouns,* the second noun may be put in the ablative, "*quam*" being omitted. In the former construction, the two things compared are in the same case, as "*Luna minor est quam sol*" = the moon is smaller than the sun (or we could say, *Luna minor est sole*). The latter construction is only used when the comparative adjective is nominative or accusative.

The Accusative Case. The accusative is the case of the direct or nearer object of the transitive verb: *e.g. Brutus Cæsarem interfecit* = Brutus killed Cæsar.

a. Some verbs, especially those of *concealing, asking,* and *teaching,* may take two accusatives, one of the person, the other of the thing, *e.g. nihil matrem celat* = he conceals nothing from his mother; *nunquam divitias deos rogavi* = never asked I riches from the gods.

b. Intransitive verbs may take a cognate accusative, *i.e.* an accusative of kindred meaning to the verb, *e.g. cursum currere* = to run a race; *duram servitutem servit* = he serves a hard slavery.

* Note. The forms *quis, quid* are substantival, *e.g. quis adest?* = who is present? But *qui, quod* are adjectival, *i.e.* used with nouns; *e.g. qui miles?* = what soldier?

c. Factitive verbs (*i.e.* verbs of *making, calling, thinking,* etc.) have two accusatives, one of the object, the other of the complement, *e.g. Ciceronem consulem creant* = they make Cicero Consul; *patriam Britanniam vocamus* = we call our country Britain.

d. Duration of time and measure of space are put in the accusative, *e.g.* '*Victoria multos annos regnavit* = Victoria reigned for many years (here, "for" = "during"); *muri erant ducenos pedes alti* = the walls were 200 feet high. ["Point of time at which" is put in the ablative.]

e. The place whither one goes is put in the accusative, and without a preposition if it is the name of a town or small island, or domum (*home*), rus (*country*), *e.g. Romam redivit* = he returned to Rome; *rus eo* = I am going into the country (*rus* is neuter). But "*in* Italiam eo," because Italy is not a town or small island.

Note. (*d*) and (*e*) are really extensions of (*b*).

f. The accusative of respect is joined to verbs and adjectives (rare in prose, common in poetry), *e.g. nudae sunt lacertos* = they are bare as to their arms; *deo similis humeros* = like unto a god in his shoulders.

g. The accusative is often used in exclamations: really object to some verb understood, *e.g. me miserum!* = wretched me! *O te ferreum!* = man of iron that thou art!

Easy Passage to be turned into Latin.

[Note on the order of words in a Latin sentence.—The verb, or if not the verb, some important part of the predicate, usually comes last of all. The verb *sum,* however, seldom concludes a sentence, *e.g. amicus est mihi carissimus.* Adjectives, when used as attributes ("a good man"), usually *follow* their noun (*vir bonus*). Adverbs usually *precede* their verbs (*graviter dixit* = he spoke weightily).]

"Little Boy Blue."

[Use the dictionary for new words.]

"Once upon a time there was a boy whose name was 'Blue' (say, to whom the name was 'Blue'). When his father had given him a horn to blow (which he might blow), he ordered his son to watch the sheep. But because this boy was very lazy, he often *used to go to sleep* (imperfect) for many hours in the fields, thinking to himself (say, with himself): 'To sleep is more pleasant than to work.' At last his father found him out: for the oxen which he was watching had entered into the meadow, and the sheep had settled in the cornfield. 'Where is Little Boy Blue?' all the men shouted. And by-and-by they found him under a haycock in the middle of a field—fast asleep! What did his father give him?"

"Little Boy Blue" in Latin.

Olim erat puer cui nomen erat Caeruleo (dat. in apposition to *cui*). Ubi pater cornu ei dederat quod inflaret, filium oves servare jussit (perf. of *jubeo*). Quia autem (*autem* is never first word in a sentence) hic puer erat pigerrimus,

multas horas in agris saepe dormiebat, secum reputans "Dormire est jucundius (neuter) quam laborare." Tandem pater illum deprehendit: nam boves quos servabat in pratum intraverant, atque oves in agro frumentario consederant (plupf. of *consido*). "Ubi est Caeruleus?" omnes conclamaverunt. Denique illum* repperertunt (perf. of *reperio*) sub foeni meta in medio agro (note that the Romans said "in the middle field") dormientem. Quid illi pater dedit? (perf. of *do, dare*).

SECTION III. TRANSLATION.

Put the following into English, using a dictionary for unknown words.

THE BEATITUDES.

Beati (sunt) pauperes spiritu: quoniam ipsorum est regnum coelorum. Beati *qui* (*a*) lugent: quoniam ipsi solamen recipient. Beati qui sunt mites: quoniam ipsi terram *hereditario jure* (*b*) obtinebunt. Beati qui esuriunt et sitiunt justitiam: quoniam ipsi *saturabuntur* (*c*). Beati qui sunt misericordes: quoniam ipsis misericordia *tribuetur* (*d*). Beati qui sunt *mundo corde* (*e*): quoniam ipsi Deum videbunt. Beati qui sunt pacifici: quoniam filii Dei *vocabuntur* (*f*).

* Better Latin to say 'quem denique repperertunt,' = "whom at length they found": use the relative often where English uses the demonstrative.

THE LORD'S PRAYER.

Pater noster qui es in cœlis, *sanctificetur* (*g*) nomen tuum. Veniat regnum tuum: fiat voluntas tua, sicut in caelo, ita etiam in terra. Panem nostrum quotidianum da nobis hodie. Et remitte nobis debita nostra, sicut *et* (*h*) nos remittimus debitoribus nostris. Et *ne* (*i*) nos inducas in tentationem, sed libera nos ab illo malo. Quia tuum est regnum, et potentia, et gloria, in secula.

NOTES.

(*a*) In full, it would be *Beati sunt ii qui*.

(*b*) Literally "they shall occupy by hereditary right."

(*c*) Future passive, third plural, of *saturo*.

(*d*) Future passive, third singular, of *tribuo*.

(*e*) Ablative of quality, = of a pure heart.

(*f*) Future passive, third plural, of *voco*.

(*g*) Present subjunctive passive, third singular.

(*h*) *Et* here = also. *Et* can mean (1) both, (2) and, (3) also, (4) even.

(*i*) *Ne* is the negative particle used with imperative and subjunctive: *non* or *haud* with indicative and infinitive. Here *ne inducas* = do not lead us. (This is not a good Latin construction: it should be perfect subjunctive, not present).

[For key to above, see Matthew v. 3–9, and vi. 9–13.]

To be continued

ENGLISH

Continued from page 348

By Gerald K. Hibbert, M.A.

Adjectives. An adjective is a word "added to" a noun to qualify it, or limit it by reference to quality, quantity, or position. There are, therefore, three main classes of adjectives:

1. Of Quality;
2. Of Quantity;
3. Of Position or Relation.

1. Qualitative, or Descriptive, Adjectives, denoting some quality or attribute: *e.g., white, ugly, thick, French, such.*
2. Quantitative Adjectives, denoting *how much* or *how many*. These include:
   a. Cardinal Numerals: *one, two, three*, etc.;
   b. The Indefinite Numerals: *many, few, some, all, enough, any, much, more, most several, sundry, certain, none* or *no* (= *not any*), *less, least, both.*
3. Adjectives of Relation, or Demonstrative Adjectives. These include:
   a. Ordinal numerals: *first, second*, etc.;
   b. The Pronominal Adjectives (adjectives which are also used as pronouns): *a, an, the, this, that, these, those, other, yon; my, thy, his*, etc.; *which, what, whether; each, every, either, neither.*

Remarks on the Above. The words *hundred, thousand, million* are nouns; we can say "a hundred," though we cannot say, "a twenty." "One hundred men" is therefore "one hundred *of* men," and in Anglo-Saxon "men" was put in the genitive case.

When *many* is used with *a* or *an* to denote a number of persons or things looked at individually, it takes a singular verb: "Full many a flower is born to blush unseen" (Gray's "Elegy"). The phrase "a many" is no longer used in good grammar (except "a good many," "a great many"), although Tennyson writes "shed a many tears."

No is a shortened form of *none*, which equals "not one." The use of *none* as an adjective is confined to Old English: "There is none other name under heaven" (Acts).

Just as many adjectives are used as pronouns (*e.g.*, "the *other* day," adjective; "hate the one and love the *other*," pronoun), so also many adjectives are used as nouns: "the merciful," "the ridiculous," "*all* is lost," "*enough* is as good as a feast." This applies sometimes to numerals: "I will not destroy it for *twenty's* sake"; "we count by *tens*."

In Anglo-Saxon adjectives were inflected for Number, Gender, and Case; but in Modern English they are indeclinable (except *this* and *that*, which have as plurals *these* and *those*).

Comparison of Adjectives. There are three degrees of Comparison: the *Positive*, the *Comparative*, the *Superlative*.

The Positive is the simple adjective, as "a *bright* light."

The Comparative compares one thing with another, and asserts that the one possesses a certain quality in a higher degree than the other: as, "a *brighter* light."

The Superlative compares one thing with many, and asserts that it possesses a certain quality in a higher degree than any of the others: as "the *brightest* light."

NOTES.

1. The Superlative is not used in comparing two objects only (except by some of the poets). It is wrong to say, "Which is the tallest of the two sisters?"
2. Certain adjectives, from their meaning, are incapable of comparison: *e.g.*, *one*, *two*, *first*, *second*, *this*, *that*, *square*, *triangular*, *perfect*, etc. We do, of course, say, "This is more perfect than that," but we are not then using "perfect" in its strict sense. Compare "The chiefest among ten thousand."

HOW TO FORM THE COMPARATIVE.

1. By adding *-er* to the positive (or *-r*, if the positive end in *e* mute): *e.g.*, *long*, *longer*; *scarce*, *scarcer*. If the positive ends in *y* preceded by a consonant, the *y* becomes *i*: *lofty*, *loftier*. If the positive ends in a single consonant preceded by a single vowel, the consonant is doubled: *fit*, *fitter*.
2. By prefixing *more* to the positive, in all cases where the positive has more than two syllables (*alarming*, *more alarming*), and in most cases where the positive is disyllabic (*decent*, *more decent*). The disyllabic adjectives that form their comparatives in *-er* are those ending in *y*, *ble*, *er*, *ow*, and those that have the accent on the last syllable (*prettier*, *nobler*, *tenderer*, *narrower*, *politer*). It is very much a matter of taste in these cases: what sounds best is oftenest used.

HOW TO FORM THE SUPERLATIVE.

1. By adding *-est* to the positive: *e.g.*, *longest*;
2. By prefixing *most* to the positive: *e.g.*, *most alarming*. The remarks on the formation of the comparative apply equally here.

The Superlative is sometimes used, not to compare one thing with many others, but to denote that a thing possesses a certain quality in a high degree: this is usually expressed by prefixing "a most" or "a very" to the positive: as, "a most extraordinary thing."

Double comparatives and superlatives are found in old writers: *e.g.*, "worser," "the most unkindest cut of all," "the most straitest sect," and (even in Modern English) "lesser."

IRREGULAR COMPARISON.

Positive.	*Comparative.*	*Superlative.*
good	better (1)	best (betest)
bad	worse (2)	worst
little	less	least
much *or* many	more	most
old	older *or* elder (3)	oldest *or* eldest
far	farther (4)	farthest
[forth, *adverb*]	further	furthest
fore	former	foremost, first
nigh	nigher, nearer (5)	nighest, nearest, next.
late	later, latter	latest, last.

NOTES.

(1) From old word *bat* = good.
(2) From Anglo-Saxon *weor* = bad.
(3) *Elder* is not used when two persons are definitely compared in point of age. We may say "an elder brother," but not "elder than."
(4) Probably formed from *far* by false analogy with *further* (which is probably from *forth*).
(5) *Nearer* is a double comparative; *near* itself is a comparative form (positive, *neah*).

Words like *foremost*, *hindmost*, *innermost*, *utmost*, etc., are probably double superlatives, as they seem to contain the two old superlative endings: *-m* (for *-ema*) and *-ost*.

Position of Adjectives. An adjective is said to be used *attributively* when it immediately precedes or follows a noun; but when the verb "to be," or some similar verb, comes between it and the noun, it is said to be used *predicatively*. Thus: "The *wise* men of Gotham" (attributive); "Heap on more wood, the wind is *chill*" (predicative).

The Articles. *A*, *an*, and *the* are sometimes called articles (Latin, *articulus* = a joint), but they are really adjectives (see above).

The is called the Definite Article, because it points out or defines: as, "The pied piper of Hamelin"; "The Maccabees." It is a weak form of the demonstrative "that." In such phrases as "The more the merrier"; "The nearer the bone, the sweeter the meat," *the* is not the article, but the old instrumental case of the demonstrative adjective *se*, *seo*, *that* (the, that), and means "by how much . . . by so much" (literally, "by how much the more, by so much the merrier").

A, *an*, are called Indefinite Articles; they are weakened forms of the numeral *one*. They show that it is *one* thing of the class which is meant, but do not specify *which*; *e.g.* "As a man thinketh in his heart, so is he." *An* is used before words beginning with a vowel or *h* mute; *a* before words beginning with a consonant or *h* aspirated, or *u* when sounded *yu*; *e.g.*, *an army*, *an heir*, *a cat*, *a horse*, *a unicorn* (but *an umbrella*). But *an* may stand before a word beginning with *h* aspirated when the accent is not on the first syllable of the word: *an historical parallel*, *an hypothesis*. Writers differ very much on this point. In the Psalms we find "an host," "an unicorn," and Macaulay has "an European."

In such sentences as "He kneeled upon his knees *three times a day*," *a* is not the indefinite article, but represents the old preposition *on* (= in).

The article should be repeated before each noun in a series of enumerations, when the nouns denote distinct things: as, "the butler and the baker of the King of Egypt." To say "the butler and baker" would imply that one man was both butler and baker. When the nouns denote things closely connected, the article need not be repeated: as "The beauty and worth of every human soul."

EXERCISE. Pick out all the adjectives in the following passage, classify them, and give comparative and superlative; say whether used attributively or predicatively:

"All the earth and air
With thy voice is loud,
As, when night is bare,
From one lonely cloud
The moon rains out her beams, and heaven is overflowed.

Chorus hymeneal
Or triumphal chant,
Matched with thine, would be all
But an empty vaunt—
A thing wherein we feel there is some hidden want."

(*Shelley*, "Ode to a Skylark.")

Correct the following sentences:

1. He is the tallest man of all the rest.
2. Which of these two do you like best ?
3. He wore a large and a very shabby hat.
4. The King sent for the Chancellor and Treasurer.
5. Milton is greater than any poet.
6. I can see two different flags, a white and green.

KEY TO SENTENCES ON PAGE 248.

1. *He* should be *him*, as *but* is here a preposition, meaning *except*.

2. *Whom* should be *who*.

3. *He* should be *him*, to be in apposition to *friend*, which is in the objective case.

4. *Cherubim* should be *cherub*.

5. *I* should be *me*, for the same reason as in the first sentence.

Pronouns. A Pronoun is exactly what its name implies, a word used "for a noun": *e.g.*, "Love took up the glass of Time, and turned *it* in his glowing hands." *It* is here used to avoid repeating "the glass of Time."

As a pronoun is a substitute for a noun, it has number, gender, and case, just as would the noun for which it stands.

Pronouns are often confused with adjectives. To test a pronoun, ask the question, "Does this word stand instead of a noun ?" If so, it is a pronoun ; if not, it is something else, probably an adjective. Thus: In "Give John that book," *that* does not stand for a noun, and is therefore not a pronoun ; it is a demonstrative adjective. But in "Give John his book and that of his brother," *that* stands for "the book," and is therefore a pronoun.

CLASSIFICATION OF PRONOUNS.

1. Personal ;	4. Relative ;
2. Demonstrative ;	5. Indefinite* ;
3. Interrogative ;	6. Distributive.*

[* Some include these two under Partitive.]

1. PERSONAL PRONOUNS. *I*, *we*, *thou*, *ye* or *you*, *he*, *she*, *it*, *they* ; and all their cases.

I and *we* are personal pronouns of the First Person (the person speaking) ; *thou*, *ye*, and *you* of the Second Person (the person spoken to) ; *he*, *she*, *it*, and *they* of the Third Person (the person spoken of).

He, *she*, *it*, and *they* are sometimes classed as Demonstrative Pronouns.

The Personal Pronouns are thus declined:

	FIRST PERSON.		SECOND PERSON.	
	Singular.	*Plural.*	*Singular.*	*Plural.*
Nom.	I	we	thou	ye, you
Obj.	me	us	thee	you
Pos.	my *or* mine	our *or* ours	thy *or* thine	your *or* yours.

THIRD PERSON.

	Singular.			*Plural.*
	Masc.	*Fem.*	*Neuter.*	*All genders.*
Nom.	he	she	it	they
Obj.	him	her	it	them
Pos.	his	her *or* hers	its	their *or* theirs

The possessive cases of these pronouns are always adjectival, and are best classed as adjectives (see under Adjectives of Relation at commencement of this lesson). The forms *mine*, *thine*, *ours*, *yours*, *hers*, *theirs* are used only predicatively: *e.g.*, "the loss is ours." Sometimes, however, in poetry and stately diction we find *mine* and *thine* used attributively, but only before a noun beginning with a vowel: "Give every man thine ear, but few thy voice" (Hamlet). The forms *my*, *thy*, *our*, *your*, *her*, *their*, are used only attributively: "my fault."

Ye was once nominative, and *you* objective, though occasionally we meet an exception, as "Lest confidence . . . deceive ye to persuasion over-sure" ("Paradise Regained"). *You* is now both nominative and objective.

Thou is now rarely used, except in poetry or addressing the Divine Being, and among the Quakers. The plural *you* gradually supplanted it, as a mark of special respect, the person addressed as *you* being supposed to be as good as many "thous." We now, of course, use *you* and *your*, whether we are addressing one person or more than one.

It is the Anglo-Saxon *hit*, the *t* being a neuter suffix (as in *what*, *that*). Its original possessive was *his*, and *its* is a modern form: *e.g.*, "The iron gate . . . opened to them of his own accord" (Acts).

The following are sometimes called *Reflexive* Pronouns, but are really Personal:

Singular.	*Plural.*
myself (ourself)	ourselves
thyself (yourself)	yourselves
himself, herself, itself.	themselves.

Also the modern form *oneself*, which has no plural ; it was originally written "one's self."

Self (which means *same*), though originally an adjective, came to be regarded as a noun ; hence *myself*, etc. In the forms *himself*, *themselves*, we see "self" used in its original adjectival sense, and *themselves* should therefore be "themself."

The form "ourself" is used by royalty. "It was ourself thou didst abuse" ("King Henry V.")

They are called *reflexive* because they are used when the action "bends back" and affects the doer: as, "He saved others, *Himself* He cannot save" (*himself* being here *objective*).

Sometimes they have no reflexive force, but are used for emphasis: as, "God Himself is with us"; "Myself am hell." Here *himself* and *myself* are in the *nominative* case.

NOTE. The objective cases of the Personal Pronouns can be used reflexively, without the addition of *self* ; as, "Get thee gone," "I'll disrobe me."

To be continued

FRENCH

Continued from page 327

By Louis A. Barbé, B.A.

Capitals and Small Letters. There are some differences between the French and the English uses of capital and small letters. We shall note chiefly the points of difference.

1. After a colon a capital is used to introduce a quotation, thus: *Aristote disait à ses disciples : Mes amis, il n'y a point d'amis* (Aristotle used to say to his disciples: "My friends, there are no friends").

2. The name of God and all words synonymous with it are written with an initial capital as in English, thus: *Dieu* (pronounced *Dee-ĕ*), God; *le Seigneur* (*lĕ Seyn-yer*), the Lord; *le Créateur* (*lĕ Crey-ah-tër*), the Creator; *l'Être Suprême* (*laytr Sü-prame*), the Supreme Being. But when the word is a compound substantive of which the component parts are joined by a hyphen, they each take a capital: *le Tout-Puissant* (*lĕ Too-Püee-sawn*), the Almighty. It is not customary to use capitals, as is done in English, in the case of *pronouns* referring to God.

3. The names of the signs of the zodiac, of the constellations, of the planets, when they are referred to as parts of the planetary system, and *le Soleil* (*Sŏ-ley-ye*), the Sun, when it is considered as its centre, are looked upon as proper names and take capitals.

4. When moral qualities and abstract ideas are personified the nouns indicating them are written with capitals, as *la Fortune* (*la for-tün*), fortune; *la Vérité* (*la vey-ree-tey*), truth.

5. No adjectives, and sometimes not even the nouns (unless they naturally have capitals) occurring in the titles of literary works, take capitals. Thus Pascal's "Thoughts on Religion" is written *Pensées sur la religion*, and Sainte-Beuve's "Literary Portraits" is in French *Portraits littéraires*.

6. The adjectives *saint* and *grand* take capitals when they are integral parts of a proper noun, as *la rue Saint-Honoré*, *la Saint-Jean* (the feast of St. John—*i.e.* Midsummer Day), *Henri le Grand*. Otherwise they are written with small initials, as *saint Jean*, *saint Honoré*, *le grand Henri*.

7. Adjectives used as substantives, to indicate a language, take no capital, thus, *le français* (*lĕ frawn-sey*), the French language; *le latin et le grec* (*lĕ la-tan ey lĕ grek*), Latin and Greek.

8. Small initials only are used:

(*a*) For the names of the months, of the days of the week, and of the points of the compass, as *janvier* (*jawn-vee-ey*), January; *février* (*fey-vree-ey*), February; *lundi* (*lun-dee*), Monday; *mardi* (*mahr-dee*), Tuesday; *le nord* (*lĕ nŏr*), north; *le sud* (*lĕ süd*), south. But when these last are used to designate a division of the globe, or a number of countries, they take capitals, as *mer du Nord* (North Sea), *empire d'Occident* (*awn-peer dŏk-see-dawn*), Empire of the West.

(*b*) For the names of the various religions and sects, and of their adherents, as *christianisme* (*cree-stee-ah-neesm*), Christianity.

(*c*) For the names of members of religious orders, as *bénédictins*, *dominicains* (*bey-ney-dik-tan*, *dŏ-mee-nee-kan*).

(*d*) For titles, as *l'empereur de Russie*, *le roi Édouard*, *le duc de Guise*; pronounced *l'awn-pĕ-rër dĕ Rüs-see*, *lĕ rwa Ed-warr*, *le dük dĕ Gweez*.

9. The abbreviations of *monsieur*, *madame*, *mademoiselle*, pronounced respectively *mĕ-see-ĕ*, *ma-dahm*, and *ma-dé-mwa-zel* (Mr., Mrs. and Miss), are *M.*, *Mme*, *Mlle*. Their plurals are written *MM.*, *Mmes*, *Mlles*. Of the forms sometimes used in England instead of these, *Mons.* is to be avoided, because it is considered uncomplimentary; *Mde.*, because it means *marchande*; and *Mdlle.*, because it is not French at all. Other abbreviations of frequent occurrence are: *Mgr*, for *monseigneur* (*mon-seyn-yër*), my lord; *Me*, for *maître*, pronounced *mey-tr*, the title given to lawyers; and *Ve*, for *veuve* (*vëv*), widow. B.C. and A.D. are respectively *avant J.C.* and *après J.C.*

10. The pronoun *je* (I) is not written with a capital.

EXERCISE I.

Indicate phonetically the pronunciation and give the meaning of the following words:

femme, *tête*, *histoire*, *aiguille*, *faubourg*, *doigt*, *péril*, *mauvais*, *Dieu*, *Espagnol*, *vérité*, *soleil*, *février*, *mardi*, *monsieur*, *maître*, *Noël*, *mademoiselle*, *nord*, *beaucoup*, *quoi*, *hiver*, *damner*, *sculpter*, *prompt*, *cuiller*, *maison*, *sous*, *misère*, *poison*, *poids*, *paix*, *sept*, *huit*, *neuf*, *dixième*, *signe*, *amer*, *prix*, *Guise*, *cri*, *babil*, *ville*, *œuf*, *sœur*, *plomb*, *mais*, *chef-d'œuvre*, *citoyen*, *gloire*.

Syllables. In dividing words into syllables, the following rules should be observed:

1. A single consonant between two vowels always belongs to the second of the two syllables, thus: *généralement* is composed of the syllables *gé'né'ra'le'ment*, generally.

2. When two separable consonants occur in the body of a word, the first of them belongs to the preceding, and the second to the following syllable, thus: *con'sen'tir*.

3. If the second of the two consonants is *l* or *r*, they are inseparable, and both belong to the second syllable, as in *trou'bler*, to trouble; *mon'trer*, to show; *é'criture*, writing.

4. If *r* and *l* themselves come together, they are separable, thus: *par'ler*, to speak; *mer'lan*, whiting; *hor'loge*, clock.

5. The consonants *nr* and *nl* are to be separated, as in *den'rée*, provisions; *s'en'rhumer*, to catch a cold; *en'lever*, to carry off; *en'lacer*, to entwine.

6. *Ll* and *rr* are also to be divided, as in *al'ler*, *ar'river*, *der'rière*, *il'lustre*.

7. The consonants *ch*, *ph*, and, except in a very few words, *gn*, are inseparable, as *four'chette*, fork; *so'phiste*, sophist; *a'gneau* (*an-yŏ*) lamb, *poi'gnard* (*pwahn-yarr*), dagger.

Liaison. By *liaison*, pronounced *lee-ey-son*, or linking, is understood the carrying

on of the final consonant of one word to the initial vowel of the next, providing the two are intimately connected in sense. In the case of a word ending in *mute e*, this applies to the consonant immediately preceding it. When carried over in this way some of the consonants change their sound. D becomes T, *un grand homme* = *un gran'-tom* (a great man), G becomes K, *un long espoir* = *un lon' kespoir* (a long hope), S and X become Z, *les amis, six enfants* = *ley-zahmee* (the friends), *see-zawn'-fawn'* (six children). In the numeral *neuf* (nine), F becomes V, *neuf ans* = *nĕ-vawn'* (nine years); P is carried on only in *trop*, pronounced *trŏ* (too much), and *beaucoup*, pronounced *bŏ-kōō* (much), *il va trop avant* = *trŏ-pa-vawn'* (he goes too far forward), *beaucoup en parlent* = *bŏ-cōō-pawn'-parl* (many speak of it). The *t* of *et* (*ey*), and, is never sounded, and therefore never carried on.

Punctuation. The punctuation marks are as follow:

1. *La virgule* (,), (*la veer-gül*).
   Le point et virgule (;), (*lĕ pwan'-tey-veer-gül*).
   Les deux points (:), (*ley dĕh pwan'*).
   Le point (.), (*lĕ pwan'*).
   Le point d'interrogation (?), (*lĕ pwan' d'an'-ter-rŏ-ga-see-on'*).
   Le point d'exclamation (!), (*lĕ pwan' d'eks-cla-ma-see-on'*).

To these may be added:

2. *Les points de suspension* (. . . .), (*ley pwan' dĕ süs-pawn'-see-on'*).
   La parenthèse (( )), (*la pa-rawn'-taze*).
   Les crochets ([ ]), (*ley crŏ-shey*).
   Les guillemets (" "), (*ley gheeyĕmey*).
   Le tiret (—), (*lĕ tee-rey*).
   L'accolade (f.), (⏜) (*l'ac-cŏ-lad*).
   L'astérisque (m.) (*), (*l'asteyreesk*).

3. In dictation the directions for opening and closing a parenthesis and inverted commas are: *Ouvrez la parenthèse* (open the parenthesis); *Fermez les guillemets*, pronounced *ferrmey ley gheeyĕmey* (close the quotation).

ORTHOGRAPHIC SIGNS

Accents. There are three accents, the acute accent (´), *accent aigu*, the grave accent (`), *accent grave*, and the circumflex accent (^), *accent circonflexe*.

The *accent aigu* is placed only over the vowel *e* to give it the closed sound, as in *témérité* (*tey-mey-ree-tey*), temerity.

The *accent grave* is placed chiefly on the letter *e*, but also on *a* and on *u*. It is placed on the letter *e* to give it the open sound, as in *après* (*aprey*), after; *succès* (*süksey*), success; *prophète* (*prŏfate*), prophet.

It is also used to distinguish one word from another, thus:

(*a*) On the preposition *dès* (from), to distinguish it from *des* (of the), and from *dés* (dice, thimbles), all pronounced *dey*;

(*b*) On the preposition *à* (to), to distinguish it from *a* (has);

(*c*) On the adverb *là* (there), to distinguish it from the feminine article *la* (the);

(*d*) On the adverb *où* (where), to distinguish it from the conjunction *ou* (or);

(*e*) On the adverb *çà* (here), and its compound *deçà* (on this side); and also on the adverb *déjà* (already).

The *accent circonflexe* occurs on all the vowels except *y*. It usually indicates the omission of a letter (*a*, *e*, or *s*), and the vowel on which it is placed is almost invariably long, thus: *âge* (*āhj*), age; *fête* (*fāte*), feast, holiday; *flûte* (*flühl*), flute; *apôtre* (*apohtr*), apostle; *maître* (*meytr*), master.

It is always placed on the vowel immediately preceding the terminations *mes* and *tes* of the first and second persons plural of the past definite, and on that immediately preceding the final *t* of the third person singular imperfect subjunctive in all verbs. Thus: *nous aimâmes* (*noo-zeymāhm*), we loved; *vous reçûtes* (*rĕsüht*), you received; *il finît* (*fee-nee*), he might finish; *il fût* (*fü*), he might be.

It is also required on the *i* of verbs in *aître* wherever that *i* retains a *t* after it throughout the conjugation, thus: *paraître* (to appear) has *paraît* in third person singular present indicative, but *parais* in the second person. When the letter *i* takes a circumflex accent it is not dotted. The *accent circonflexe* is also placed:

(*a*) On *dû*, the masculine singular form of the past participle of *devoir* (to owe), to distinguish it from *du* (of the), both pronounced *dü*;

(*b*) On the *u* of *mûr* (ripe), to distinguish it from *mur* (wall), both pronounced *mür*;

(*c*) On the adjective *sûr* (sure), to distinguish it from *sur* (on), both pronounced *sür*.

Exercise II.

A. Indicate the silent letters in those of the following words that have any:

automne, histoire, sang, août, doigt, septembre, porte, champ, sud, portent, plomb, danger, lac, vingt, mer, faubourg, paix, outil, blanc, prix, Jésus, nez, cerf, beaucoup, baril, péril, monsieur, amer, chez, clef, sculpter, baptême, hier, coup, porc, corps, dans, damner, homme, hache, serf, drap, sous, mais, neuf, bord, gentil, gosier, et, thé.

B. Divide the following words into syllables, and give their meanings:

laurier, chaloupe, sourcil, plaisir, mardi, vérité, après, fourchette, agneau, poignard, généralement, ami, écriture, parler, merlan, montrer, troubler, denrée, virgule, consentir, enlacer, beaucoup, devoir, déjà.

The Apostrophe. The apostrophe is like a comma, placed a little above the line ('), to indicate the elision or omission of the final vowel of one word, before the initial vowel or mute *h* of another, as *l'objet*, for *le objet*, *l'homme* for *le homme*, *j'ai* (I have) for *je ai*.

Elision takes place, and is indicated by an apostrophe:

1. In the masculine and feminine singular forms of the definite article, *le, la*; thus, *l'oiseau* (*lwa-zŏ*), the bird, for *le oiseau*, *l'aiguille* (the needle) for *la aiguille*. *Yeuse* (evergreen oak) is the only word beginning with *y* that requires elision in the article preceding it, *l'yeuse*, pronounced *lee-ĕz*; elision does not take place before

onze (eleven) and its derivatives, or before *oui* (*wēē*), yes, when used as a noun.

2. In the pronouns *je* (I), *me* (me), *te* (thee), *le* and *la* (him, her or it), *se* (himself), *ce* (this), both pronounced *sĕ*, *que* (which), in the preposition *de* (of or from), the conjunction *que* (that), and in *ne*, the negative particle, thus: *j'aime* (I love), *il s'amuse* (he amuses himself).

There is, however, no elision in *le* and *la* when they come after a verb—*e.g.*, *donnez-le à l'homme*, pronounced *don-nēy-lë à l'öm* (give it to the man).

3. In *lorsque* (when), *puisque* (since), and *quoique* (although), but only before *il* (he), *elle* (she), *on* (one), *ils* (they), *elles* (they), and *un*, *une*, the indefinite article.

4. In *quelque* (*kel-kë*), some, but only in the expressions *quelqu'un* (m.), *quelqu'une* (f.), (some one), pronounced *kelkun'* and *kel-kün*.

5. In *presque* (almost), but only in the word *presqu'île* (peninsula).

6. In *jusque* (as far as, until), *e.g.*, *jusqu'à Paris* (*jüska Parē*), as far as Paris; *jusqu'alors* (*jüskalorr*), till then.

7. In *entre* (between), when it is the first component of a compound noun, as *entr'acte* (interlude), or of a compound verb, as *s'entr'aider* (*saun'tr-ēy-dēy*), to help one another.

8. In *aujourd'hui* (*ō-joor-düē*), to-day.

9. There is an apostrophe in *grand'mère* (*graun'-merr*), grandmother, and a few similar words, although there is really no elision.

10. The vowel *i* is elided only in the one word *si* (if), and only when it precedes *il* (he), or *ils* (they).

11. When the pronouns *moi* (me, to me), *toi* (thee, to thee), come after a verb, and before *en* (some, of it), the two vowels *oi* are elided, thus: *donnez-m'en* (*dön-ney-maun'*), give me some.

The Cedilla. The cedilla (*la cédille*) is placed under the letter *c* (ç), when the letter, though occurring before one of the vowels *a*, *o* or *u*, requires to be pronounced with the hissing *s*-sound which it naturally has before the other vowels. Thus, there is a cedilla under the *c* of *façade* (*fasahd*), facade; *garçon* (*garrson'*), boy; *reçu* (*rèsü*), received.

In words which are not written with a cedilla the *c* retains its hard sound, as *calcul* (*kalkül*), calculation; *cocarde* (*kokard*), cockade; *écu* (*ēykü*), shield.

The Diaeresis. The diæresis is two dots (¨) placed on the second of two vowels, to indicate that it ought to be pronounced independently, and that the sounds of both vowels are not to be merged into one diphthong, thus: *haïr* (to hate), *naïf* (simple), *Ésaü*, to show that the words are to be sounded *ha-ēēr*, *nah-ēēf*, *Esah-ü*, and not *hèr*, *nèf*, *Eso*.

Exercise III.

A. Name the accents in the following words: *même*, *bergère* (shepherdess), *blé* (corn), *mûr dès*, *mère* (mother), *déjà*, *paraît*, *côté* (side), *près* (near), *prés* (meadows), *tête*, *été* (summer), *fâché* (sorry, angry), *fenêtre* (window), *lèvre* (lip), *être* (to be), *à*, *où*, *dû*, *général*, *maître*, *succès*, *témérité*, *île* (island).

B. Elide the vowel and put an apostrophe wherever it is required in the following sets of words:

Je ne ai de autre ambition (I have no other ambition); *ce est moi* (it is I); *la oreille* (the ear); *le homme*; *le oiseau*; *il faut que il parte* (he must go away); *la crainte que elle me a causée* (the fear which she has caused me); *lorsque un enfant ne obéit pas* (when a child does not obey); *si il vient* (if he comes); *le héros*; *la héroïne*; *presque en même temps* (almost at the same time); *quelque autre* (some other); *le onze juillet* (the 11th July); *jusque à Londres* (as far as London).

The Hyphen. The hyphen is a stroke (-) placed between words to indicate that they are intimately connected, and form a single word or expression as regards meaning. Thus: *chef-d'œuvre* (masterpiece) and *moi-même*, pronounced *mwah-māme* (myself).

1. In compound substantives, usage is not consistent with regard to the hyphen. Thus, whilst *chef-d'œuvre* takes it, *trait d'union* (*trey-dün-yon'*), itself the French word for hyphen though quite as much a compound word, is written without it. In other words, it is arbitrary.

2. In proper names, both of persons and of place, component words are joined by a hyphen, thus: *Gay-Lussac*, *Clermont-Ferrand*. It is also customary to join the several Christian names of an individual by hyphens, as *Jean-Jacques Rousseau*.

3. Pronouns coming immediately after a verb, and standing to it in the relation of subject or object, are joined to it by a hyphen. If there are two such pronouns two hyphens are used. Thus: *Donnez-le-moi* (give it to me).

4. Hyphens are required both before and after the euphonic T, used in certain tenses after the third person singular, when followed by *il*, *elle*, *on*, as *parle-t-il?* (does he speak?)

5. When *ci* and *là* are joined as enclitics to a noun or pronoun, a hyphen is required, thus: *celui-ci* (this one), *celui-là* (that one), pronounced *së-lü-ēē-sēē* and *së-lü-ēē-la*, *cet homme-ci* (this man) *cette femme-là* (that woman). When prefixed to certain words they are joined to them by a hyphen, as in *ci-après* (hereafter).

6. The tens and units of a number are joined by a hyphen, except where the conjunction *et* (and) comes between them, thus: *dix-neuf* (19), but *vingt et un* (21). There is also a hyphen between *quatre* and *vingt* in the numbers from 80 to 99, thus, *quatre-vingts* (80), *quatre-vingt-dix* (90). *Cent* (100) is not joined by a hyphen to any number whether coming before or after it; thus 210 must be written *deux cent dix*, pronounced *dēh sawn' dēēss*.

7. *Même* (*māme*), self, is joined by a hyphen to the personal pronouns—*e.g.* *moi-même* (myself), *eux-mêmes* (themselves).

To be continued

MUNICIPAL ENGINEERS & SURVEYORS

Engineers and the Public Service. Qualifications, Salaries and Duties of Engineers, Surveyors and their Assistants

By ERNEST A. CARR

Expert Views and Advice. A valuable introduction to our detailed survey of the various departments of local government work is afforded by some practical advice to candidates as to the Municipal Service generally, and the best methods of qualifying for it, for which we are indebted to the courtesy of the Town Clerk of Manchester, the Solicitor and Clerk to the Wallasey District Council, a leading official of the Borough of Croydon, and other experts. These views have been furnished for our exclusive benefit, and are specially useful from the fact that they are no text-book theories, but the utterances of practical men of wide experience.

All are agreed that, although for certain scientific posts previous municipal experience is not essential, it is very important that candidates generally should enter the Service as early as possible.

"In the municipal, as well as in any other service," says the Wallasey authority already mentioned, "there is no royal road to success, but only the beaten track of hard work and strenuous endeavour.

"To become a good municipal servant it is desirable that a person should either be articled or apprenticed to the Chief of one of the various staffs of a Corporation. A parent who is well enough off to do so should article his son in preference to apprenticing him, as, although in the former case he will generally receive no salary for a term of years, he obtains more quickly such qualifications as will enable him to compete for the responsible positions of the Service. One great advantage of a youth passing through the drudgery of an apprenticeship is that, if he has brains to enable him to qualify for a professional position, his practical knowledge will give him a far better—because more intimate—command over his staff."

The Value of the Specialist. A further point emphasised is the importance of specialising from the first. The men who succeed are they who early determine which branch of the Service best suits their tastes and capacity, and who steadfastly pursue their training with that special object in view. "As to the course of instruction for municipal posts," writes the same expert, "first a good general education and then a practical training in the department to which the candidate wishes to attach himself, constitute as good a course as I know.

"The principal Departments of a Corporation are those of the Town Clerk, Borough Surveyor, Gas Engineer, Water Engineer, Electrical Engineer, Accountant or Treasurer, Police, Tramways and Education. Other Departments are the Public Libraries, Parks, Markets, Baths, etc."

On the question of diplomas and similar qualifications another official states: "The various professions are now so well filled with capable men that it is necessary for a candidate for any municipal position of value to be able to pass a very stiff examination, or to possess high qualifications as to his knowledge of the work of the department he seeks to enter."

Seeking Posts. Students in doubt as to their fitness for local government duties will be interested to learn, on the authority of an official of twenty-one years' service, that the most successful officers are not necessarily the book-worms and "intellectuals." "Even amongst 'brainy people,'" he writes, "there is often a truly woeful lack of initiative. In the Municipal Service there is room for the individual of ability, and still more of originality, courage and administrative capacity. Such an officer will be always able to command and retain a position of great responsibility at a good salary."

How is a qualified candidate to obtain an appointment? On this question the replies of the experts may be summarised as follows: He should forward a list of his qualifications to the clerk of each public authority in the district, stating the class of post he seeks and asking that he may be informed of any vacancy arising. He should scan the advertisements headed "Municipal" in the daily press, and the "Official Announcements" of trade and professional journals. But his best chance is to study every week the advertisements of the newspapers devoted wholly to Local Government affairs. These contain all requisite particulars of any appointment vacant, and specify the method of applying for it. It is a frequent practice of the authorities to require a successful candidate to undergo a medical examination before he is appointed.

The Demand for Municipal Experts. Year by year Science has played an increasingly prominent part in the conduct of local affairs. In the palmy days of the vestries, it was considered beneath the notice of practical men. Then came the beginnings of modern sanitation and engineering; the despised subject was found to possess more than a theoretic value, and to be capable of solving problems too complex for the old "rule of thumb" methods. Electricity developed with incredible speed from a schoolroom study to a mighty yet tractable monster, capable of unheard-of feats in the public service. Chemistry was employed to expose the fraudulent trader,

bacteriology shed new light on the mysteries of infectious disease, the local authorities forsook their prejudices, and to-day Science stands acknowledged as the most beneficent handmaid of the common weal.

The natural consequence has been a rapidly growing demand throughout the Municipal Service for trained scientific experts, able to apply their special knowledge to the wants of local government. A distinct class of officials has thus sprung up, with positions well in advance of the ordinary clerical and administrative staff; and among the most responsible and best-paid scientific posts are those connected with municipal engineering and surveying.

Salaries. To illustrate the salaries paid by municipal bodies to their leading engineers, we may turn to the pay lists of the Manchester Corporation. This energetic body, which employs a large technical staff for its gas, water and electrical undertakings, remunerates the leading officers as follows. Surveyor, £1100 a year; Gas Engineer, £1000; Superintendent, £700; Electrical Engineer and Tramway Manager, £900 each; Water Engineer, and Surveyor of Mains, £600.

It would be easy to multiply instances like this. Newcastle's engineer receives £800 a year, rising to £1000; a similar post at Leeds is remunerated with £600, while the engineers in charge of the waterworks and sewage works of the latter city each receive £1000 a year. The general question of salaries, however, will be discussed a little later. These examples are intended merely to show how attractive is this branch of the Service.

It is but fair and just that responsible posts of this class should be handsomely remunerated. To provide a large town with a proper water supply from remote sources, to devise satisfactory sewerage systems, or establish generating stations and supply services for electric lighting and traction—these are among the vast practical problems referred to the engineer's judgment. Such undertakings involve an outlay of many thousand pounds—perhaps even several millions; and their cost is largely determined by the way in which they are planned and carried out under his supervision. With issues so grave dependent on his work, it must be admitted that the municipal engineer is worthy of his hire.

The Scope of the Service. Many engineering works undertaken by local authorities are not compulsory, and the engineer is not always, therefore, an indispensable member of the staff. There is, however, a rapidly deepening conviction among persons interested in local government, that public services such as tramways or gas supply, instead of resting in the hands of trading companies, should be carried on by the authority itself. The effect of this has naturally been to widen the field of activities for municipal engineers of every grade. Nowadays many urban districts boast a small engineering staff of their own, whilst the larger and more enterprising boroughs have each a strong force. There is every prospect that for many years to come the scope of the engineer in municipal work will continue to expand.

Candidates for municipal employment should spare no effort to attain professional standing, or at least to establish proof of their competency, through one of the recognised examining bodies of the engineering calling. In the present course, however, we need not discuss the technical training or the examinations to be undergone before such diplomas can be gained. These questions are fully dealt with in the sections devoted to engineering itself [see CIVIL, ELECTRICAL and MECHANICAL ENGINEERING]. We are concerned simply with the practical considerations affecting municipal engineering as such. Briefly, these resolve themselves thus: What are the duties and salaries of municipal engineers and their assistants? What qualifications, and especially what practical experience, are most in demand in connection with such posts?

The Chief Posts. The field of inquiry is so wide that it must be mapped out into separate tracts corresponding with the special needs of local authorities rather than with the professional boundaries. For practical purposes we may classify municipal engineers as follows:

Borough Engineer.
Surveyor.
Electrical Engineer: General, Lighting, Tramways, or Consulting.
Waterworks Engineer.
Gas Engineer.

We shall now discuss only the chief and assistant posts of the first two classes. The remaining sections will be dealt with in due course.

The duties of a Borough or City Engineer vary with the special needs of each district. In a river port he may be mainly concerned with docks and sluices, and the clearing of fairways. A coast area involves such tasks as the construction of breakwaters and shore defence works. Hilly country has also its own problems—notably, road engineering and storm-water drainage.

The Borough Engineer. The borough engineer is required to have a thorough practical knowledge of civil, sanitary and electrical engineering, and of building construction. He must be familiar with the principles of mechanical construction and design, an expert in taking levels and drawing plans, and in preparing specifications, estimates, and bills of quantity. He may be called upon to design main drainage and water supply systems—or any other engineering work a local authority may lawfully undertake—and to supervise the execution of all such works. He is placed in control of all bridges and tunnels, and also of the engines, pumps, lighting appliances, tramway tracks, generating stations, dust destructors, and other mechanism belonging to the council; and must advise that authority as to their repair and renewal. And not least important among the duties entrusted to him is the scrutiny of all engineering contracts in order to safeguard municipal interests.

In many towns the offices of engineer and surveyor are united. The additional duties need not, however, detain us now. They will

be considered in discussing the surveyor's position.

The Engineering Societies. The professional qualifications expected of candidates for the post of borough engineer depend on the views of the authority concerned. The larger boroughs regard with greatest favour the Membership and Associate Membership of that most ancient and distinguished of engineering societies, the Institution of Civil Engineers [see page 160]. The "M.I.M.E." is also held in high esteem; and, among additional qualifications, the diplomas of the following bodies are most frequently met with: the Electrical Engineers', Sanitary Engineers' and Surveyors' Institutions, and the Sanitary Institute.

Many competent engineers, whose training would fit them for municipal duties, and who are conspicuous in the career of every successful candidate for valuable public appointments, and is so important that a few instances of such careers may be found helpful.

One municipal prize-winner, after serving four years' articles to a civil engineer engaged in water, sewage and railway practice, spent two years in acquiring architectural experience, and three more as engineer and agent for a contractor for large public works, including the construction of roads, bridges and main sewerage systems. A term of municipal surveying added valuable practice in innumerable duties relating to streets, parks, tramway systems, etc.; and the experience thus acquired has secured for its possessor the engineership of a leading northern city.

The record of another engineer who, at the age of thirty-two, has lately won a municipal

EXAMINATIONS FOR MUNICIPAL AND COUNTY ENGINEERS

Examining Body, Time and Place of Examination.	Subjects of Examination. No exemption from any part of the examination is granted to candidates, but certain certificates of general knowledge in English and Mathematics are required.	Fees and Age Limit.
INCORPORATED ASSOCIATION OF MUNICIPAL AND COUNTY ENGINEERS. London: April. In one Provincial Town: October. In Scotland: As required. In Ireland: As required.	**1. Engineering as applied to Municipal Work:** 1st Paper: A. Sewage Disposal. B. Tramways Construction. C. Bridge Construction. D. Water Supply. 2nd Paper: A. Geodesy. B. Hydraulics. C. Sewerage. D. Road Construction and Maintenance. **2. Building Construction; Strength of Materials:** A. Materials. B. The Construction of Public and Private Buildings. C. Building By-laws. D. Public Baths and Hospitals. **3. Sanitary Science as Applied to Towns and Buildings:** A. Heating and Ventilation. B. Scavenging and Disposal of Refuse. C. Water Supply and Drainage of Buildings. D. Disinfection. **4. Municipal and Local Government Law as Relating to the work of Municipal Engineers and Surveyors.**	£4 4s. for first examination. On re-examination after failure £2 2s. Candidates must have attained their 22nd birthday.

Note.—The Examiners do not recommend any particular text-books, as it is desired to make the examinations rather a test of the candidate's practical knowledge of the subjects generally than to find his acquaintance with any particular book or books.

Fifty per cent. of the total number of marks given are required to constitute a pass.

Further particulars, with specimen question papers, may be obtained from the Secretary to the Association at 11, Victoria Street, London, S.W.

attracted to the Service, have been unable to follow the course of studies prescribed for membership of the Institute of Civil Engineers, or for any similar professional diploma. Practical experts of this class should avail themselves of the examinations of a body devoted solely to the municipal aspects of their calling—the Incorporated Association of Municipal and County Engineers. This is a powerful organisation, restricted in membership to trained engineers and surveyors to public authorities. A table of its examinations is given on this page.

The Supreme Essential. It will be readily understood that no certificates, and no amount of theoretic training, will supply the place of that foremost essential, viz. responsible experience in engineering works of a varied and comprehensive nature. This fact stands out post with a beginning salary of £800 a year, is mainly associated with giant railway works and contracts all over the country. These undertakings involved such varied duties as the alteration of street levels, the construction of bridges, viaducts, canals and wharves; and the making and sewering of new roads. In most of these works he was the responsible engineer in charge of the contract. It is noteworthy that, unlike the majority of his rivals, this officer had had no previous service under a local authority.

First Steps. A more typical career, perhaps, is that of the present Southend borough engineer, who has much brilliant municipal service to his credit. His articles were served in a borough engineer's office, and since that time as assistant, and later as principal, he has been engaged on public works, including ordnance

map surveys, extensive main drainage and storm-water schemes, the designing of public baths, schools, pumping stations and other borough buildings, and sundry street and tramway works. Solid achievement and variety of experience being so essential, it follows that candidates whose years do not reach the middle thirties are seldom regarded as ripe enough for chief appointments. On the other hand, those over fifty are often considered past their best.

Enough has been said to indicate that there is no royal road to a borough or county engineership. But with such a goal in view, a student cannot begin more favourably than as articled pupil to an official of that standing—preferably a member or associate member of the Institution of Civil Engineers—in a busy provincial town. In this way valuable insight into municipal work will be gained, as well as a good opportunity of securing a footing in the Service.

Instances of the salaries paid by the larger corporations have already been given. Speaking generally, they vary between £500 and £1200 a year. Minor authorities pay less—from £350 to £550 a year. But these bodies rarely appoint a chief engineer. Their practice is to employ gas, electrical and other specialists as required, whilst the place of the borough engineer is occupied by the municipal surveyor.

The Municipal Surveyor. Many educational works classify appointments of this character among the posts available to men who have undergone the training of a general surveyor. This is true to so limited an extent as to be really misleading. Property or estate, as well as building, surveyors are occasionally included in the staff of a public authority, and are the municipal representatives of professional valuation or quantity surveying, usually holding the Fellowship or Professional Associateship of the Surveyors' Institution [see SURVEYING]. But where the post is that of "borough surveyor" the training expected of that officer, and the duties entrusted to him, are substantially those of an engineer.

In order to explain clearly the surveyor's duties, and the way in which they differ from those of a borough engineer, it is necessary to note that there is a broad distinction to be drawn between surveyors to a *county* or *district council* and those in the service of a *city* or *borough*. Whatever the character of the public authority he serves, a surveyor is not called upon to undertake such grave and costly mechanical schemes as may occupy the attention of the municipal engineer. Elaborate water services, for instance, with reservoirs and lengthy conduits, the formation of docks and harbour defences, or the devising of an important main drainage scheme, would lie outside the scope of his duties; though many borough surveyors gladly undertake responsible work of this nature for the sake of an enhanced reputation. On the other hand, the expert surveyor carries out minor engineering works equally with the engineer; and, in addition, is burdened with a mass of miscellaneous duties in connection with roads and the land surface generally, from which his brother official is wholly or partly free.

County and District Surveyors. Under a public authority for a county, urban, or rural district, the duties involved are practically those of a Surveyor of Highways. The officer is responsible for surveying, levelling, maintaining and repairing all roads and bridges in his charge. In an urban or rural district he supervises generally the work of road cleansing, watering, paving and lighting, and of laying out and sewering all new thoroughfares in his area. Street lamps, hydrants and trees are under his care, and occasionally the maintenance of tramway tracks. He acts also as expert adviser to his authority in matters of contract. He must be, in brief, a sound road engineer and a capable draughtsman.

The smallest responsible posts are naturally in the rural districts, where traffic is least and new streets work is unimportant. The salaries paid are correspondingly small—£100, £120 or £150 a year, rising to £180 or £200. But there is ample leisure for private work or study, and these appointments afford good openings into the Municipal Service for young men who must earn a livelihood while qualifying for higher positions.

In urban districts the duties are heavier and more responsible, including inspection of buildings in course of construction; and salaries range from £150 to £250 a year—occasionally over £300. County authorities require their surveyors to be expert engineers, for the work involved may include the reconstruction of important county bridges. The officers appointed are usually members either of the Surveyors' Institution, the Institution of Civil Engineers, or the Association of Municipal and County Engineers. If private practice is prohibited, the salary paid varies from £400 to £800 or £1000, according to the area and importance of the county. In a recent and typical instance, a stipend of £500 was offered, rising by £50 annually to £700. Some of the smaller county councils, by imposing no restrictions as to private work, secure the services of competent prac'ising surveyors and engineers for £250 or £300 a year.

Borough Surveyors. The busiest and best-paid section of municipal surveying is that of the leading cities and boroughs, including the metropolitan divisions.

The Borough Surveyor is a great deal more than a surveyor of highways. To the duties of that office, magnified as they are by the importance and business of his district, must be added multifarious other tasks in engineering, land surveying and architecture. The most important of these are the construction and repair of tramway tracks, the carrying out of street widening and improvement schemes, the clearance of "condemned areas," the formation of public gardens and recreation grounds, and the inspection of houses and sewers in course of construction. It is only in the largest towns, as we have seen, that a borough engineer is employed; and where this

is not the case, the surveyor has general charge of municipal machinery and apparatus. Further, he is often called upon to act as architect for his council in the designing of public baths, libraries, schools and other buildings, and to superintend their erection.

For such responsible work one must be experienced in far more than land surveying. The borough surveyor's practical training should be as diverse as the engineer's, and of the same general character. Except for the increased importance of architectural knowledge, all that has been said of the experience and diplomas best suited to the equipment of a borough engineer applies equally to surveyorships. Indeed, a highly qualified officer of either class is fully competent for the other, and such transfers are not infrequent. The best degree for surveyors is the A.M.Inst.C.E.; or, failing that, the Associateship of the Surveyors' Institution [see page 160].

The remuneration is similar to that of the borough engineer, and the proportion of liberally paid posts is high. Minor boroughs pay their surveyors from £200 to £500 a year; the larger towns from £400 to £800, £1,000, and even higher. Manchester pays its chief surveyor £1,100, and its district officials £340—in one instance £400. The City Corporation, small as its area is, pays its surveyor £1,000 a year. In the London boroughs the stipend varies from £500 to £900, with travelling allowances.

Assistant Engineers and Surveyors. To the young student of engineering and sanitary service, with his experience still to come, and his way in the world yet to make, the principal appointments of the class we have been considering are as yet beyond reach. Such a student, if the question of a living wage be important and an articled pupilship out of the question, would be well advised not to seek municipal employment directly he leaves his technical college or school of engineering. Without practical experience, the only posts in the Service available to him would be office positions—perhaps as plan-copier or draughtsman. As we shall notice when considering municipal clerkships, such appointments are not ill-paid, but they lead further and further from actual engineering; and the student, remembering the supreme importance of practical knowledge in the career he seeks, should resolutely turn his back on the Municipal Service for a time.

A year or two spent on the outdoor staff of a public contractor or civil engineer will put such a youth in a very different position. He will now be competent to take a post as Assistant in a municipal surveyor's or engineer's office. His training thereafter will be of the most practical and useful nature: he will learn exactly the scope of municipal work, and, if he has ability, and does not neglect the science and theory of his subject, will be well on the way to his goal of a principal appointment

It is worth noticing, by the way, that a distinction is often drawn between a Surveyors' Assistant and an Assistant Surveyor, the latter being the senior and more responsible post.

Candidates for assistantships are required to be capable draughtsmen, practically acquainted with drainage and street work, and experienced in the preparation of specifications, quantities and estimates. For the best appointments competence to superintend outdoor works is usually stipulated; and if the vacancy is in a borough surveyor's office, some knowledge of architectural work is commonly demanded.

The Duties of an Assistant Surveyor. The work expected of an Assistant is of precisely the same character, whether he is employed in an engineer's or surveyor's office; but vacancies of the latter class are by far the more frequent. The following typical "List of Duties," recently prescribed by an urban district council, will be of practical service to students preparing for such posts.

The Assistant Surveyor must reside in the district, and devote his whole time to the duties of the office. He will act under the control and superintendence of the Surveyor to the Council. The undermentioned duties appertain to the office:

1. To make surveys, take levels, and prepare drawings, tracings, specifications and estimates for private street works; for construction of all sewers and drains, and for works of street improvement.

2. To assist in the preparation of drawings, tracings, specifications, and estimates of all other works of every description required by the Council from time to time.

3. To assist in the checking of accounts, the inspection of all new buildings, streets and sewers, and in the supervision of the various branches of the Council's work, and all works the Council may have in hand from time to time.

4. To be in attendance at the meetings of the Council and the various Committees.

5. Generally to assist the Surveyor in the discharge of his duties, and to perform any other duties appertaining to the Surveyor's Department that the Surveyor may direct.

Salaries of Assistant Surveyors. Assistants' salaries vary like those of their chiefs. For the appointment to which the above list relates, £120 was offered, with annual increments of from £10 to £150. In provincial towns and the London boroughs the surveying staff is classified into juniors and seniors; the former receiving from £80 to £175, the latter not less than £150, rising to £200 or £225, and more generally an initial salary of £180 or £200, with a maximum of £300. If the staff is large, the chief assistant's stipend begins at £250 and may rise to £400. The usual limits of age are—for juniors, 19 to 25; for seniors, 25 to 35 or 40.

It will be seen that a moderate income is attainable even as an assistant surveyor or engineer. But in the Municipal Service no hardworking and able officer of good general education should allow himself to remain in that status all his life. The fatal mistake which renders such stagnation possible is to neglect one's opportunities of qualifying professionally at the earliest possible moment. To work hard at one's duties and studies at the same time is admittedly trying; but it is essential for the man who means to succeed.

To be continued

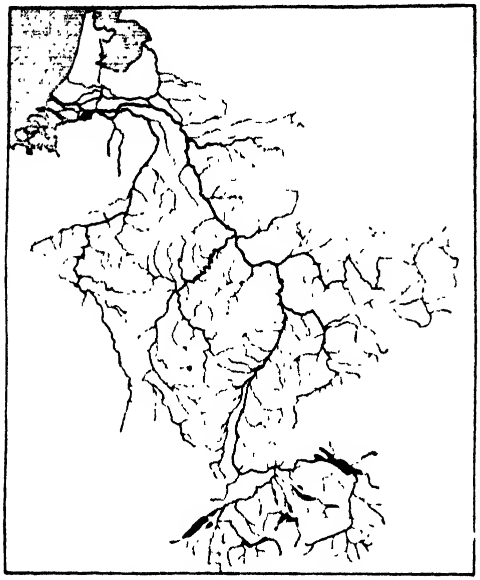
Continued from page ...

THE SHAPING OF THE EARTH

Rain, Rivers, Oceans, Lakes, Mountains. The Streams and Rivers as Nature's Sculptors. Glaciers and Volcanoes and their Work

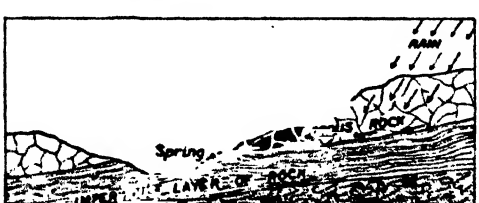
By Dr. A. J. HERBERTSON and F. D. HERBERTSON, B.A.

WATER, which plays its part, as we have seen, in determining the shape of the earth, does more than help to make new soil out of the waste of the rocks. It carries the new soil down to the lower lands, and spreads it out over them. Everyone who has built a sand castle by the sea knows that next day the sand is perfectly smooth again. The waves have moved the grains of sand, and spread them out level. The same thing happens in every flood. The swollen river overflows the lowlands, its waters discoloured with the soil it whirls along with it. As it subsides it drops over the flooded area the particles of soil which it has no longer the force to carry. The same process goes on imperceptibly after every shower. Wherever there is the slightest slope there is a downward movement of particles of soil and water towards the lowest level. Thus all over the earth a levelling movement is going on, wearing down mountains, and building up the plains with new soil made from their broken-down rock waste.



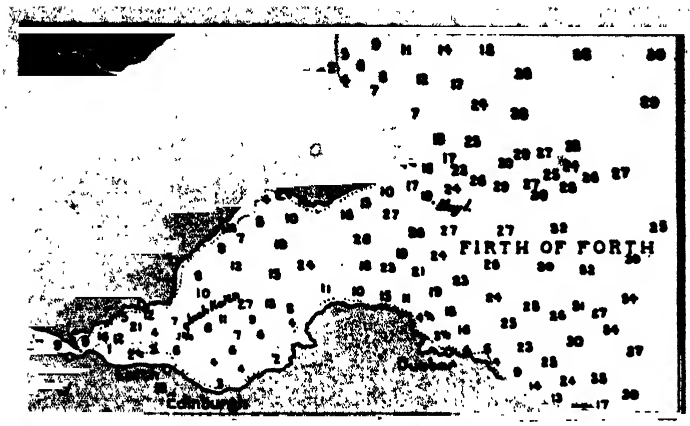
26. BASIN OF THE RHINE
Showing the course of the river and its tributaries

Trees as Protectors of the Earth. These processes that go on eternally are evidently as much creative as destructive, though man may desire to check them so far as possible, because they interfere with his requirements. In many mountain lands the hillsides are so stripped of soil that the inhabitants have to collect it from far below to replenish their little plots. This destruction of the soil, or denudation, as it is called, is greatly checked by trees, which not only break the force of wind and rain, but also bind the soil together with their roots, so that it is less easily washed away. What is true of forests is true of all vegetation, and men are now turning this knowledge to account. In the hot desert, for example, the sands are slowly but steadily driven before the wind in long sand dunes, which advance so many inches or feet in a year. Whole cities have been buried by them in the deserts of Asia, and the railways which now cross many deserts are menaced by the same fate. To protect them, coarse grasses and desert trees are planted alongside the tracks to bind the sands together and arrest their movement. In lands of the temperate zones the forests on the hill slopes have been so recklessly cut down that the lower slopes are unfit for cultivation. Most civilised governments are now paying great attention to reforesting, in order to arrest this disappearance of the soil.



27. SECTION OF A SURFACE SPRING

The Making of a River. A river is a body of water, holding rock waste in suspension, and moving along a defined channel, or bed, from higher to lower levels. Every drop of rain which does not sink into the ground moves downwards, following the slope of the surface, seeking the lowest attainable level, and carrying more or less of the surface soil with it. Trickles of water collect into rivulets, and these into larger and larger ones, always seeking lower levels, and gradually joining up to form a main stream. The whole of the area thus drained is called a river basin. The higher ground separating one basin from another is called a *water-parting*, or a *divide*. The streams which unite to form a main stream are called the *head waters*, or *sources*. Branches which enter well-defined



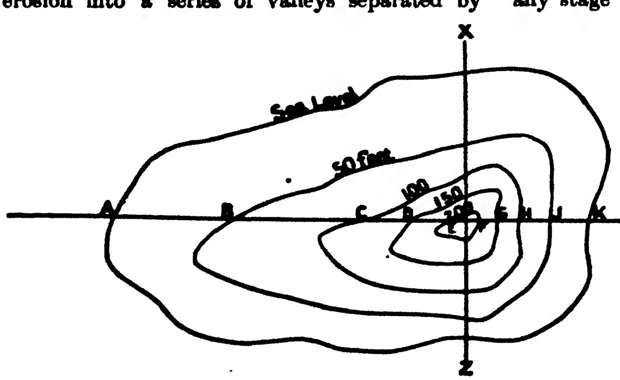
28. THE FIRTH OF FORTH, SHOWING DEPTHS IN FATHOMS AT LOW WATER. THE DOTTED LINE ROUND THE COAST IS THE 3-FATHOM LINE

streams are called *tributaries*. Where a tributary enters there is a *confluence*. The bank of a river which is on the right hand of a traveller going towards the sea is the right bank. The other is the *left bank* [26].

Character of a River's Course. The upper course of a river rising at any height is usually very steep, with great falls in its bed. Every river, however, by perpetually grinding rock waste over these obstructions, is gradually removing these inequalities, or grading its bed, as it is called. It is also deepening it, and gradually cutting out, or eroding, a valley, with more or less steep sides, according to its age and the nature of the rocks. Each of its tributaries, and the streamlets which feed them, is doing the same, and thus in the course of ages a highland region is cut up by stream-erosion into a series of valleys separated by higher ground, forming the hilly or mountainous regions we know. It is in its upper course, where it is too swift and steep for navigation, that a river does most work in wearing down the rock waste it carries. As the slope lessens its speed slackens, and it begins to drop more and more of the sediment it is carrying, thus further levelling its bed. In the plains it frequently overflows its banks, forming stretches of flat land on both sides, called its *flood plain*. Here it is probably navigable, or can be made so artificially. This process is called *canalisation*. Most of the rivers of Europe are canalised, and connected by canals, which may, perhaps, be called artificial rivers. Across the

29. THE FIRTH OF FORTH, SHOWING DEPTH OF WATER BY CONTOURS AND SHADING AT INTERVALS OF 10 FATHOMS

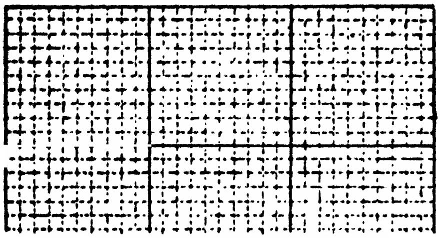
lowlands the river, now much slower, continues to seek the lowest level—that is the sea. At any stage of its course it may have found its way thither blocked by a range of mountains or hills. One of two things then must happen. Either the river has been turned in a new direction, and flows round the base, or, if the rocks are of a kind easily acted on by water, it may have cut a passage or gorge through them. The steepness of the walls of this gorge, like that of the walls of its upper valley, will depend partly on the length of time during which weathering has been proceeding, and partly on the character of the rocks and the rate at which they weather. The Thames, which rises in the Cotswolds, in which it has cut its upper valley, has to cut through



30. MAP OF CONTOUR LINES

two other barriers—the Oxford Heights and the Chiltern Hills—before it reaches the sea.

The River's Entry to the Sea. A river enters the sea by its mouth, the character of which depends on the nature of the sea into which it flows. If this has strong tides and currents, the sediment, or fine rock waste, which



31. DIAGRAM OF SECTIONAL PAPER

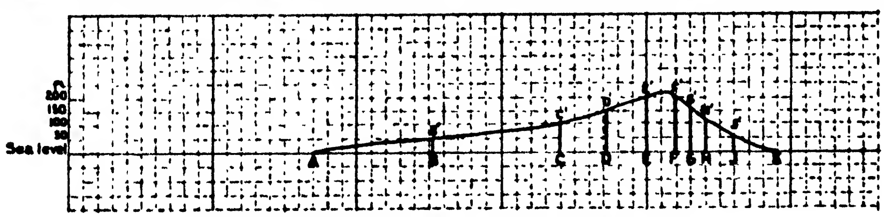
the river has brought down with it, and which it drops when its motion is checked by the sea, is rapidly carried away, and the channel is kept deep and unobstructed. This forms an estuary, up which the tides penetrate twice daily, enabling shipping to pass easily up and down. In a sea with feeble tides and currents the dropped sediment accumulates on the bottom at the river's mouth, gradually silting it up. In the course of ages the new land thus formed rises above the surface, forming mud flats of alluvial land. Across this sodden new land the river has to find its way, and, having no banks to confine it, it breaks up into a network of branches, or distributaries. At the mouth of each of these the same land-making process is going on, and the new land is steadily pushed out to sea, forming a fan-shaped delta, so called from its resemblance in shape to the Greek letter Δ of that name.

Underground Stores of Water. A certain amount of rain percolates through the ground, until it is stopped by rock of a kind through which it cannot pass. Along this layer of impervious rock it makes its way underground until the layer comes again to the surface of the land at a lower level. Here it bursts out as a spring [27]. Where the arrangement of the rocks makes this impossible, it forms a sort of underground reservoir. Coal mines are often flooded by miners accidentally breaking into such subterranean rivers or reservoirs. This underground store of water helps man in his attempts to make use of the drier regions of the world, as we shall see.

Lakes and Rivers. A lake is a body of water surrounded by land. Lakes are of all sizes. They are usually drained by a river, and are then fresh. Lakes with no outlet become salt or brackish.

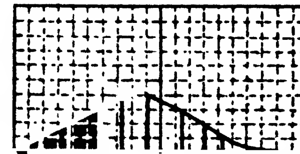
Where a river enters a lake its motion is checked, and it deposits much of the sediment it carries. All lakes thus tend to be filled up. A shallow lake is often divided into two by the formation of an intersecting belt of new land, where the river enters. A lake in a river's course thus acts as a filter, and the river which entered it as a muddy stream may emerge bright and clear at the other end.

Highlands and Lowlands. Next to the distinction between sea and land, perhaps the most important to man is that between highland and lowland, mountain and plain. Mountains, we saw, have a colder climate than lowlands, and consequently different vegetation, occupations, and mode of life. They interfere with communication, often cutting off for many months all intercourse between villages on opposite slopes, which are only a few miles distant as the crow flies. In a highland region the question of routes becomes very important. These are generally supplied by the river valleys, by following which it is possible to reach a pass or col, the lowest part of the ridge or range. In text-books of geography the highest points are generally given, whereas it is the passes, or lowest accessible points, on which communication depends, that we want to know.



32. PROFILE OF CONTOUR OF LINE A TO K ON 30

Old and Young Mountains. We have seen that the greater part of the sculpturing out of a highland region into mountains and hills has been the work of streams, which in cutting out their own beds, and carrying away loose material, have gradually shaped the present feature of the landscape. These processes have been going on for varying periods in different parts of the world. In older mountain regions, where they have been longest at work, the peaks are less sharp, the slopes less steep, the valleys broader, and more or less graded, forming good routes. In young mountain regions, uplifted in



33. PROFILE OF CONTOUR OF LINE X TO Z ON 30

comparatively recent times, where erosion has gone on for a much shorter period, the peaks are sharp, the valleys narrow, and very imperfectly graded. The upper valleys are often mere precipitous gorges, useless as routes. Such regions are almost inaccessible till man cuts or carries roads along the steep walls of the valleys. In the Himalayas, which are young mountains, the roads are often carried on frail supports along the face of precipices of the most terrifying description.

Glaciers and their Work. Where mountains rise above the snow line, the height of which varies in different parts of the world, their summits have, so far as temperature is concerned, a polar climate. Snow cannot lie to any depth on their steeper slopes, and the bulk of it accumulates in the higher valleys, where it is pressed by its own weight into solid ice. Glaciers erode valleys precisely as rivers do. Often hundreds of feet thick, and many miles long, they have an imperceptible but steady movement downwards, carrying with them the rock waste which falls from the peaks and precipices above. Some of this forms moraines on both sides of the glacier, but much falls through the crevasses, or splits in the glacier, which does not yield so easily to the inequalities of its bed as a river. The friction of the moving glacier and of the rock waste below it gives a curious U-shape to the bottom of the valley. Where we find such valleys we know glaciers formerly filled them, and ice-scratchings can often be seen on their rock walls. When a glacier reaches a certain level, its lower end, or snout, begins to melt and flow away as a river, often hollowing out a beautiful glittering blue ice cave. The rock waste, brought down in the moraines, is deposited at the lowest level reached by the glacier, often forming what look like chains of hills across the valley. Glaciers advance and recede at different periods, and several chains of these terminal moraines can often be traced where glaciers are steadily retreating or have wholly disappeared.

Volcanoes: "Chimneys" of the Earth's Interior. Volcanoes serve as outlets for the molten rock of which some part of the earth's interior consists. They communicate by a sort of pipe, or vent, with lower depths than any reached by man in his deepest mines. From the crater, or upper end of this vent, eruptions take place from time to time. They frequently begin with subterranean eruptions, which blow great clouds of steam and ashes into the air. The falling ashes gradually build up a conical mountain round the vent. In severe eruptions lava, or molten rock, may rise up the vent, flow over the rim of the crater, down the mountain sides, and over the neighbouring country. When cooled it forms a hard rock, on which nothing grows. This is gradually reduced to fine soil by the processes described, and the soil is extremely fertile, probably owing to the presence of chemical fertilisers.

Volcanoes are very irregularly distributed, but are usually near the sea. They occur in the polar regions, on the equator, and under the sea. They vary in height from 20,000 feet to mere hillocks. *Geysers* somewhat resemble volcanoes in their action, but emit hot water instead of lava.

Maps not showing the distribution of high and low land, or relief, are useless for many practical purposes. The sailor must know the depth of the sea bottom, or he may run aground. The cyclist wants to know if a given road is flat or has a dangerous hill. A railway engineer, or an army on the march, wants very precise information as to the lie of the country. The geographer can form no opinion about a country till he knows its general relief. The mapping of relief, therefore, is of great practical importance.

High Land and Low Land. A sea-chart is usually covered with figures, which show at what depth the bottom will be found [28]. On some charts lines are drawn through all places where the depth is the same—10, 20, 30, or more fathoms, as the case may be [29]. Every point on one of these lines, which are called *contour lines*, is at the same distance above the sea bottom.

The height of the land above sea-level has been more or less roughly ascertained all over the world. In civilised countries highly-trained surveyors, working under the orders of the government, make very minute and exact surveys by the aid of delicate instruments [see SURVEYING], and these are recorded in official Ordnance Survey maps. The various heights are either inserted on these maps in figures, as in sea-charts, or joined by contour lines drawn at given distances. Every point on the same contour line is at the same height above sea-level. In maps of large areas on a small scale, in which only the broad general features are shown, it is sufficient to put in contour lines for every 500 or 1,000 feet, as the case may be. Such a map would be useless to the cyclist. The more detail we want to show, the more contour lines we must put in, and our map must, therefore, be on a large scale. Wherever contour lines approach each other closely the land falls and rises more rapidly than when they are further apart. Comparing the contour map and section [30, 31], we see that in the one case the slopes are steep, and in the other more gentle. In many modern atlases the variety of relief is made more graphic by colouring the spaces between the contour lines, the intensity of the tint varying with the height, so that the highest parts are the darkest.

Sometimes hill-shading is used instead of contour lines. The steep slopes are shown by dark shading, or closely drawn thick lines running in the direction of the slope, while gentle slopes are indicated by light shading, or by thin lines at wider intervals.

Contour Maps. A student must practise translating contour maps into representations of the actual relief. For this purpose it is useful to make a few sections from contour maps, which is easily done. Figure 30 indicates the relief of a district by contour lines drawn for sea-level—50 feet, 100 feet, 150 feet, and 200 feet. We rule on a sheet of paper five equidistant lines, or, what

is better, take a sheet of fine chequer paper [31]. We number the lines "sea-level," "50 feet," "100 feet," "150 feet," "200 feet" [32]. Now suppose we want to draw a section along the line *A K*. We measure off a line *A K* along the line representing sea-level on the chequer paper, and mark on it the points *B, C, D, E, F, G, H*, and *J*, all measured exactly to correspond with the same distances along the line *A K* in the contour map.

We name them to correspond, and then draw perpendicular lines through *B* and *J*, which are on the 50-feet line in the contour map to the 50-feet line on the chequer paper. Let us call the points where they cut it *B'* and *J'*. In the same way we draw lines through *C* and *H* to cut the 100-feet line in the points *C'* and *H'*. Similar lines through *D* and *G* to cut the 150-feet line at *D'* and *G'*, and finally through *E* and *F* lines to cut the 200-feet line in *E'* and *F'*. Each point on the contour lines is now represented on the corresponding line on the chequer paper, and at the proper distance. We draw a line through the points *A, B', C', D', E', G,' H', J'*, and *K*, and thereby see what the actual surface of the country along the line *A B* is like. Do not forget, however, that the height is probably exaggerated. The lines *E E'* and *F F'* represent only 200 feet, while the line *A K* may represent any distance according to the scale of the map. A map made to show the true height would generally be too small to be clear. Notice that the long gentle slope of the hill corresponds with the less close contour lines, and the short steep slope with the closer contour lines. In 33 is shown a section of the same hill along the line *X Z*. A little practice will enable us to read contour maps right off without first translating them into sections.

The Continents. An island is a mass of land wholly surrounded with water. The greater part of the land on the earth's surface is grouped into two great islands, the Old and the New World. The former and far larger of these consists of Eurasia in the north, separated by ill-defined boundaries into Europe to the west (3,800,000 square miles), and Asia to the east (17,000,000 square miles); and of Africa in the south (11,500,000 square miles), united to Eurasia by the narrow neck or isthmus of Suez. The island of the New World is divided into North America (9,000,000 square miles) and South America (7,000,000 square miles), united by the long narrow isthmus of Central America. The island of Australia (3,000,000 square miles) is also reckoned as a continent. It is believed that an island continent (generally called Antarctica) of vast extent surrounds the South Pole. Of islands not reckoned as continents the largest is the polar island of Greenland (500,000 square miles). Islands which rise on the continental shelf may be regarded as detached portions of the mainland.

Land and Water. By far the greatest proportion of land is in the northern hemisphere, and in temperate latitudes. Only two continents, Africa and South America, are crossed by the equator, and both narrow rapidly south of it. Australia is the only continent lying wholly in the southern hemisphere. Broadly speaking, the northern hemisphere is the hemisphere of land, and the southern hemisphere is the hemisphere of ocean. The earth could be bisected in such a way that one hemisphere contained almost no land, while the other was composed almost equally of land and water. In the latter the mouth of the Loire, in France, would be approximately in the position of the pole.

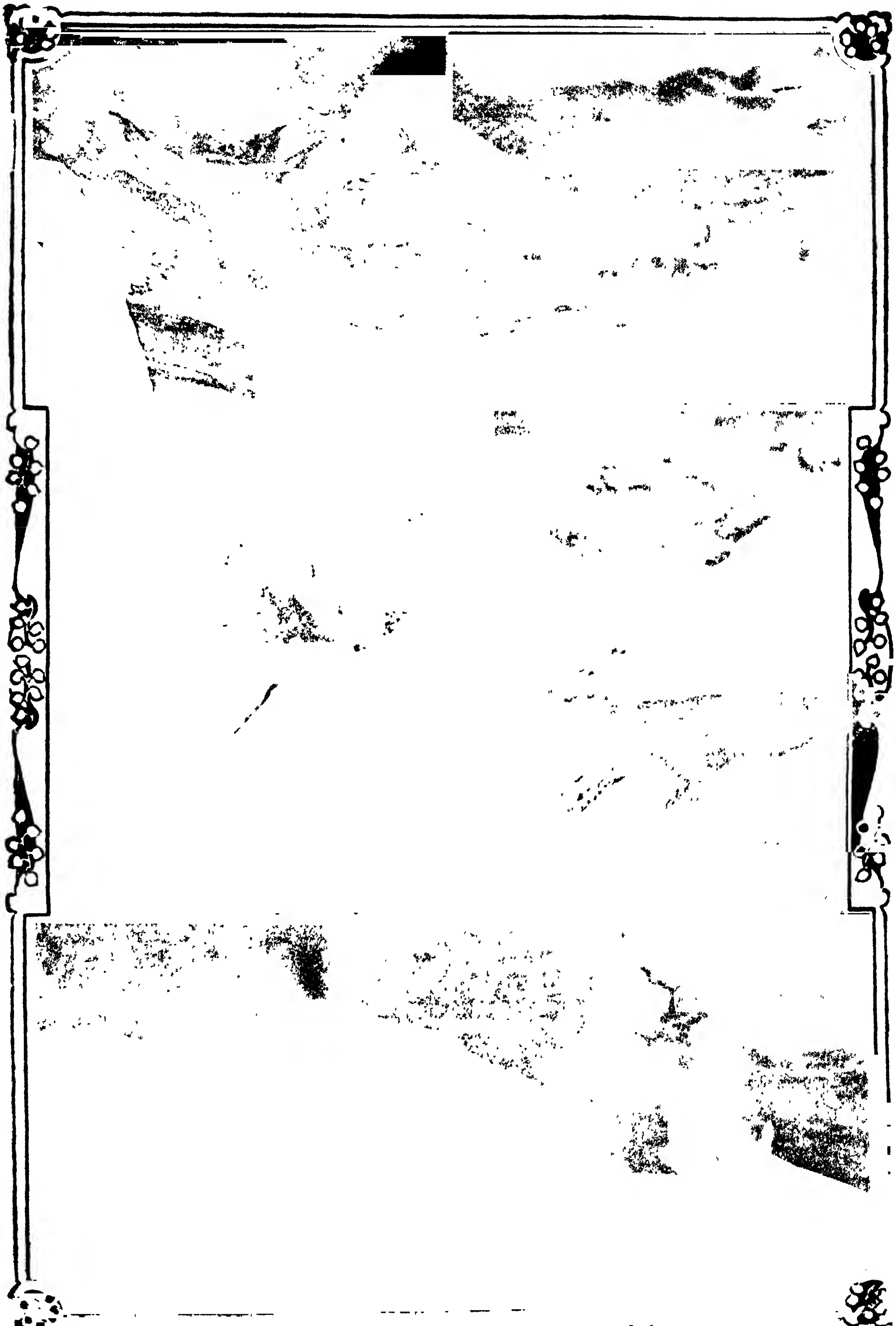
In comparing the continents we at once notice certain resemblances. The first is the tapering to the south, already mentioned, which is seen in Greenland, North and South America, Africa, and Australia (Tasmania). Another is the southward running peninsulas which characterise Europe and Asia. We may notice, too, that the general lines of the Old World, broad in the north, tapering in the south, resemble those of the New World, especially if we include Australia (Tasmania), and compare its position with that of South America. There is also a certain uniformity in the distribution of relief. Notice the so-called Mid-World and Pacific Mountain systems, which may be traced in the mountains of Central Europe, North Africa, Central Asia, the islands of the Pacific from Japan to New Guinea, and the lofty mountains of North, Central, and South America.

THE OCEANS

Five sevenths of the lithosphere are covered with water, forming the hydrosphere. The oceans and seas of the world form one great ocean, above which the higher parts of the lithosphere rise as islands of varying size.

Area of the Oceans. For convenience, this great world-ocean is known under different names. The Pacific Ocean (70,000,000 sq. miles), the largest, washes the western shores of Asia and Australia and the western shores of the New World. It communicates on the north with the Arctic Ocean, extending towards the North Pole, and on the south with the Antarctic Ocean, extending towards the South Pole. It communicates round the south of South America with the Atlantic Ocean (25,000,000 square miles), connected, like the Pacific, with the Arctic and Antarctic Oceans, which washes the eastern shores of the New World and the western shores of the Old. The Atlantic Ocean communicates round the south of Africa with the Indian Ocean (17,000,000 square miles), which washes the eastern shores of Africa, the southern shores of Asia, and the western shores of Australia, south of which it is connected with the Pacific. Various great gulfs of these oceans are known as seas. We notice the Caribbean Sea with the Gulf of Mexico, sometimes called the American Mediterranean, enclosed between Central America and the West Indies; the North Sea, enclosed between the British Isles and Europe, and the Mediterranean, enclosed between Southern Europe and Northern Africa. All these are gulfs of the Atlantic. In the Indian Ocean we see the long, narrow, almost land-locked Red Sea, between Asia and Africa.

To be continued



VOLCANOES AND GLACIERS

34. GLACIER DU GÉANT. 35. THE MARJELEN SEE. 36. A VESUVIUS EXPLOSION LASTING EIGHT SECONDS, 11.30 P.M. AUGUST 8, 1906. 37. THE ALETSCHORN GLACIER. 38. LAVA ON VESUVIUS. 39. VESUVIUS: A VIOLENT EXPLOSION

Group 10

ELECTRICITY

3

Continued from page 372

TYPES OF ELECTRIC CELLS

Including Volta's Cell, Leclanché Cells, Daniell's Cell, Dry Cells, with instructions regarding the care and testing of cells

By Professor SILVANUS P. THOMPSON

IN the article "How Electric Currents are Generated," it was pointed out that in order to set electricity flowing as a current, it is needful to provide some contrivance such as a dynamo or a battery which is capable of setting the electricity into movement, or, in other words, can exert an *electromotive-force*, or electric effort. Dynamos are mechanical contrivances for exerting an electromotive-force to drive the current along the circuit. *Batteries* are chemical contrivances to do the same thing. They are sometimes called *galvanic batteries* in honour of the Italian, Galvani, who was a pioneer in the discovery. Sometimes they are called *voltaic batteries*, in honour of Count Alessandro Volta, who was their actual inventor. Both terms refer to the same thing. The electric current itself was at one time called the galvanic current, or the voltaic current, for the same reasons.

The Cell. Every battery is made up of a number of separate cells joined together; and it is in the cells that the chemical operations proceed which propel the electricity around the wires constituting the circuit. The cell is the source of the electromotive-force which drives the current. In accordance with the principle that the production of electric energy requires the consumption or expenditure of an equal amount of energy of some other kind, we have to regard the cell as an apparatus in which energy that has been previously stored is liberated by chemical action and transformed into electric energy.

Every schoolboy knows that every kind of fuel is a store of energy. Coal represents the energy of the sunlight in past ages stored up chemically, every pound of coal containing some ten million foot-pounds of energy. Every other kind of fuel is likewise a store of energy, which, when it is burned, it gives out in the form of heat. In a *cell* the fuel which constitutes the store of energy is the metal *zinc*. Zinc will burn. A bit of zinc foil when lighted burns with a brilliant blue flame, giving out heat and light: so we know that it is a fuel. But as a fuel it is inferior to coal, for one pound of zinc will give out when burned only about 1,800,000 foot-pounds in the form of heat.

The Emission of Energy. In our cells, however, we do not want heat, and we do not set the zinc to blaze. We cause it to burn in a quiet, cool, chemical manner by dissolving it in acid or in some suitable chemical solution. In this case the chemical union of the metal with the oxygen or with the chlorine of the liquid is not called combustion; it is called chemical combination. The point of importance is that when we cause the zinc to consume quietly by chemical combination in the cell, it gives out its energy not as heat and light, but silently in an electrical way, expending the energy in pushing the current around the circuit. If a cell is badly constructed so that it offers within itself a considerable resistance to the flow of the current, it will get hot in operation, which is undesirable. A cell is a sort of little electro-chemical furnace, in which zinc is the fuel, and in which if it be properly designed, the consumption of the fuel is slow, quiet, and cool.

Volta's Cells. To make a Volta's cell, very simple appliances are needed; but to find out by experiment what it will do needs more expensive apparatus. Procure a piece of sheet copper, say 6 inches long and 2 inches wide, and a piece of sheet zinc about the same size. Take also a common jam-pot or a glass vessel of similar style, say 4 inches in diameter and 5 inches high. A glass jar is preferable, because it lets the interior be seen. Some copper wire—common bell wire, for example—not too thick, should be procured. A few feet of No. 24 standard wire-gauge will suffice. Two clamping screws should be procured by which to attach a bit of copper wire to each of the metal plates. As exciting liquid for the cell there should be provided 2 oz. of sulphuric acid, diluted down to one-fifth strength by carefully adding it a little at a time to 8 oz. of water. It will be necessary to provide also a few drops of quicksilver.

Practical Experiments. By way of preliminary experiments, fill the jar to about 4 inches deep with the dilute acid. Then dip the copper plate into it, holding it upright, and watch its surface. Nothing will happen; but the acid will clean the surface of the copper, which when taken out after a few minutes may be dried with a rag. Now try dipping into the acid, in the same way, the zinc plate. If the zinc is ordinary commercial sheet zinc you will see that at once a number of small bubbles form on its surface and come fizzing to the top. The zinc is, in fact, being consumed by the acid; idly, without the production of any useful result in the way of an electric current, and the energy of the portion consumed will turn into heat, as will be discovered if the zinc be left in too long; for the acid in the jar will grow hot as the zinc dissolves.

Now remove the zinc sheet from the acid, lay it down on a common plate, and pour upon it one drop of quicksilver, then with a bit of rag rub the quicksilver over the zinc. Instead of running off it will stick to the zinc, and can be spread all over it, making it shine almost like silver. This operation is called *amalgamating* the zinc, and it makes it beautifully clean. If

you now try the effect of dipping the zinc once more into the dilute acid you will find that if you have cleaned the whole of the surface that is immersed, the acid will not now act on it, and no more bubbles will rise from it. In fact, pure zinc is not consumed when put into dilute acid. The bubbles that arose from the dirty zinc were hydrogen gas, a product of the chemical action upon the dilute acid.

Experiments with Volta's Cell. So far we have been experimenting with the metal plates separately. We must now make up the Volta's cell by putting into the acid in the jar both of the metal plates at once. They should be put in separately, and supported with bits of wood or otherwise held so that they do not touch one another, and so that the upper end of each of the plates stands above the level of the liquid.

A Volta's cell consists of two plates of different metals—in our case zinc and copper—*dipping into dilute acid* (or other corrosive liquid) in a suitable containing vessel. Our cell [4] answers to this description. If we look at it we shall see that as arranged neither of the metals is consumed. There are no bubbles given off, neither is any electric current generated. Now try the effect of letting the top of one of the metal plates touch the top of the other. The moment they touch something happens: there will be seen a rush of minute bubbles which fizz off through the acid. Observation will show that these bubbles are now formed not on the surface of the zinc but on the surface of the copper. Is the copper then being consumed? Not at all. If you will make a special investigation by working with plates that have been carefully weighed on a delicate balance before the experiment and are weighed again after it, you will find that though the hydrogen bubbles fizz off from the copper it is the zinc that will have lost weight, some of it having been consumed.

Try the effect of making the two plates touch one another under the liquid instead of above the surface. You will find that the same effect results as before. Now try whether this effect—the chemical action evidenced by the evolution of bubbles—happens if, while keeping the two plates apart, you bring a third piece of metal into contact with both of them so as to form a bridge between them. To serve as bridge you may try another strip of sheet metal, or a bit of copper wire. You will observe that if there is a metallic bridge joining them, the effect will be just the same as if they were to touch one another—bubbles will rise from the copper plate when contact is completed, and they will stop rising when contact is broken. Try with other kinds of metal; a clean iron nail, a dirty nail, a silver florin, a bit of lead pipe, a brass knob. You will find that *any* metal will answer, provided it is clean, so that it makes a good metallic contact.

A Wire Circuit. Now attach (preferably by clamping screws or *terminals*, or failing these by soldering, or riveting or squeezing on) to each of the plates a piece of copper wire, as shown in 4. Once more observe the cell, and see what happens when the two ends of the wires are made to touch one another. The effect will be just the same as before. When they touch, bubbles will rise, showing that chemical action is going on in the cell. As soon as they are parted, the chemical action will stop.

Now try whether this effect will occur if you use very long wires. Let the wires be long enough to reach into the next room, and get a friend to help you in the experiment. If he, in the next room, brings the ends of the wires into touch, at that moment you will see the rush of bubbles on the surface of the copper plate in the cell. You could readily contrive a secret sort of telegraph this way, by agreement as to signals made by these evolutions of bubbles! Only you must be careful that the two wires do not accidentally touch one another. It would, in fact, in this experiment be better to use *insulated wires* that have been *protected* all along by being overspun with a layer of cotton (better still double-covered with two layers).

In experiments such as these we begin to realise that something really goes on *in the wire* at the time when the chemical action goes on in the cell. We see that the circuit plays an important part in the operation. In fact the chemical action—that useful chemical action which drives the current—does not occur *unless there is a complete circuit* from the zinc surface, where the energy is being given out, through the liquid to the copper, and then round the conducting wires back to the zinc. We have got our first notions of an electric *circuit*.

Simple Experiments with a Bell. For the next experiments we shall need an ordinary electric trembling bell—a well-made one. We shall also want an ordinary electric bell-push to serve as a key or switch to complete the circuit. Let us first find whether our Voltaic cell will generate a strong enough current to ring the bell. Take some copper wire and join up a circuit with a wire from the copper to the bell-push (screwing the end of the wire to one terminal), another wire stretching from the second terminal of the push to one terminal of the bell, a third wire returning from the other terminal of the bell to the zinc of the cell as in 9. When we have joined up our circuit rightly with good, clean metallic joints, then let us press the button of the push to complete the circuit. The bell ought to ring. If it does not one of three things must be amiss: either our Voltaic cell is not powerful enough, or the bell is out of order, or there is something wrong with the circuit.

We can easily test whether the bell is at fault by trying to ring it by substituting for our Voltaic cell some known suitable good cell such as a Leclanché cell (of which we shall learn later). If the Leclanché cell will not ring the bell, we must examine the mechanism of the bell to see if the adjustment is faulty—or else procure a new bell.

Having made sure that the bell will ring when the button is pressed, next take a number of Voltaic cells, two, three, or four of them, joined up in a row, the copper of one to the zinc of

the next as in 10, and so on, so that the current from the first flows on through the second and then through the third, in series. We have thus built up a *battery of cells*, and when we try them on the bell we shall find that it rings more powerfully than with one cell.

Further Experiments. Try the effect of leaving the circuit completed so that the bell goes on ringing. If the cell used has been newly made up, it will begin to ring vigorously, but in a few moments will ring more feebly and then stop. In fact, a Volta's cell of zinc and copper is very inconstant, and *runs down* quickly. It will recover again in a few minutes if allowed to rest *with the circuit open*, but if you leave it *short-circuited* (that is, with its circuit *closed*), it will run down worse than ever.

Try whether lifting either of the metal plates out of the acid will make the cell recover; you will find that lifting out the zinc does no good, but lifting out the copper for a few minutes and then putting it in again has a beneficial effect. It helps the copper to get rid of the adherent film of hydrogen bubbles which is the cause of this falling off in power. Now try some more experiments. Find whether it makes any difference to the bell if the circuit is altered so as to go to the bell before it goes to the push, or if the push is near the bell instead of being near the cell, or if the connections to the cell are reversed.

Next procure a simple table *galvanometer*, or detector galvanometer, such as can be bought for three or four shillings. A galvanometer [see Chapter on ELECTRICAL MEASUREMENT] is an instrument which, when we pass an electric current through it, will indicate on a dial whether there is a current or not, and whether the current is weak or strong.

Take such a galvanometer and join it up [11] in circuit with the Voltaic cell and with a press-button, by copper wires, just as you did before. When you press the button, and so *make the circuit*, you will see the galvanometer needle swing to one side, and if you keep the button pressed down the needle will settle down pointing in an oblique direction at one side of the zero on the dial. When you release the button and so *break the circuit*, the current stops, and the needle flies back to the zero of the dial.

Now try the effect of reversing the sense of the cell; loosen the copper wires from the terminals and join to the zinc the one that was connected to the copper plate, and join to the copper the one that was joined to the zinc [12]. On again pressing the button, the needle of the galvanometer will be deflected—but in the other direction on the scale.

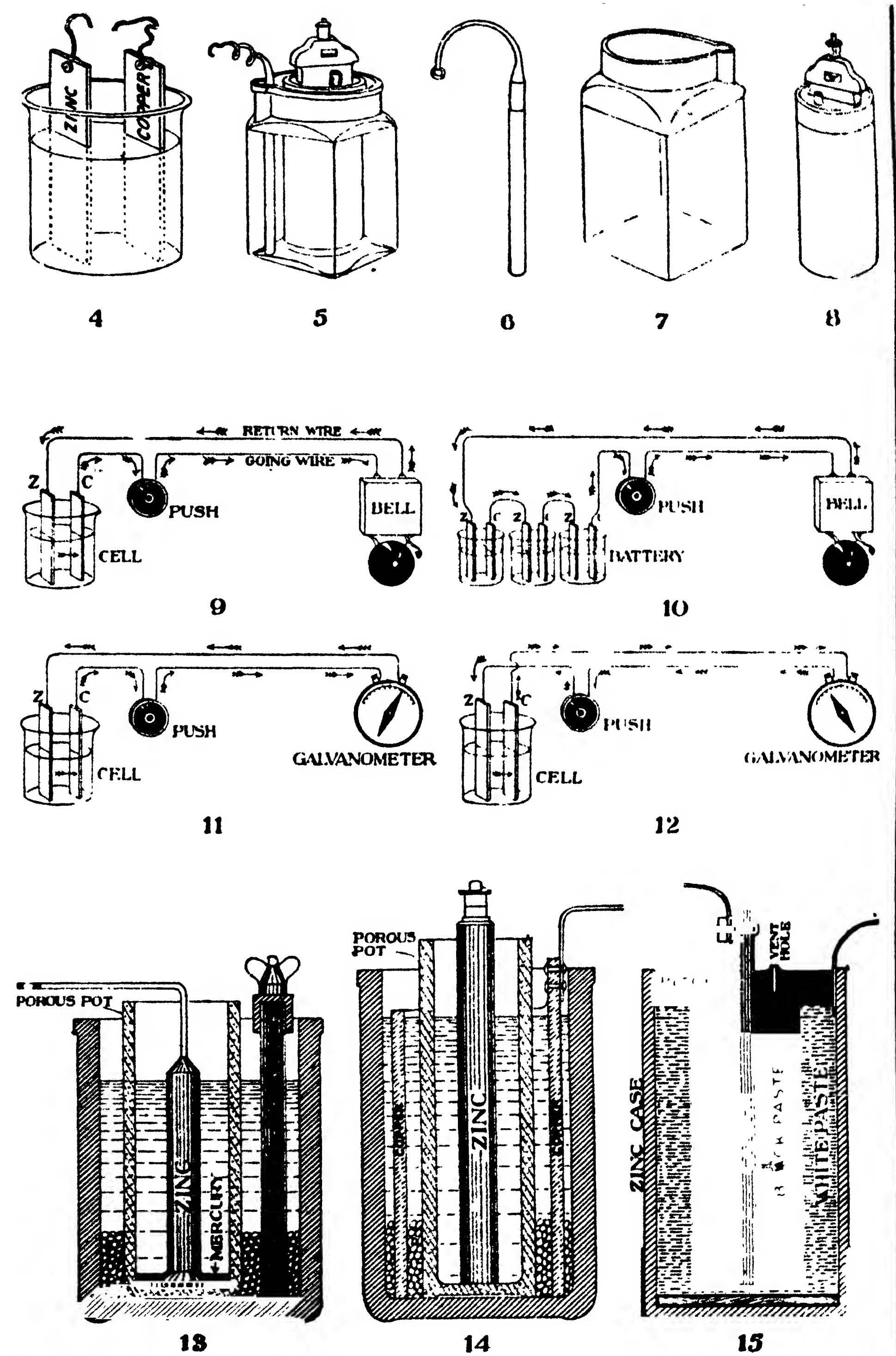
Conductors and Non-conductors. Having a galvanometer and a cell, we can now try a number of substances to see whether they will conduct or not. We should join a wire from one terminal of the cell to one terminal of the galvanometer, and then fasten to each of the unoccupied terminals a piece of wire a foot or two long. If we were to complete the circuit by bringing together the two free ends of these two pieces of wire the galvanometer would at once show the presence of a current.

But if, instead of making them touch one another, we bring them both to touch a third substance, if that substance is a conductor it will complete the circuit by making a conducting bridge between the two wires. Lay down a coin on the table, and bring both the wires to touch it; at once the galvanometer will show a current, because it conducts. Try other coins or pieces of metal. All metals conduct. Try a piece of wood, or glass, or porcelain. None of them conduct: they are called *non-conductors* or *insulators*. Try a piece of leather, a cork, a piece of chalk. Try dipping the two ends of the wires into water or vinegar. Water (unless chemically pure) and all wet things will conduct; but we may not be able to observe the current through them unless we use, instead of one cell, a battery of several cells.

If we use a battery of several cells, it will become more evident that all moist things conduct the current. But it is now time to speak of better cells than the simple Volta cell; for it has already been shown to be unsatisfactory for continued use on account of its inconstancy. In fact, if it be tested with a cell-testing voltmeter [see ELECTRICAL MEASUREMENT], though when newly set up it may show an electromotive-force of over 1 volt, its electromotive-force will have dropped to about 0·62 of a volt, when its copper pole has become covered with a film of hydrogen.

Leclanché Cell. This cell is made in millions for use in electric bell work. Its general form is seen from 5. The fuel consumed in it is zinc—in this case a rod of zinc with a wire cast in at the top [6]. This rod stands in a containing-pot of glass [7], and dips into a liquid made by dissolving in water some crystals of sal ammoniac. This liquid is less corrosive than dilute sulphuric acid, but acts for this purpose equally well as an excitant. No copper plate is used, but instead there is a slab of hard carbon having a terminal screw fastened into its upper part. But this carbon plate does not dip directly into the excitant liquid. If it did, we should have the same old trouble of the hydrogen bubbles interfering with the action of the cell. To avoid this it must be embedded in a substance called a *depolarizer*, which in this case consists of a granular mass of crushed carbon and black oxide of manganese. As this granular mass must not be allowed either to fall to the bottom of the cell or to touch the zinc, it is packed up around the carbon plate inside an inner pot of porous porcelain, as shown in 8. This pot is porous so as to let the excitant soak through, and also to let the current pass; for non-porous porcelain would be a non-conductor.

The *depolarizer* is for the purpose of destroying the hydrogen bubbles formed during the working of the cell; so that during the periods of rest, when no current is being taken from the cell, the carbon plate may become depolarized, that is, freed from the interfering films of hydrogen gas.



DIAGRAMS ILLUSTRATING TYPES OF ELECTRIC CELLS

A good Leclanché cell will have an electromotive-force of 1·45 volts.

Care of Leclanché Cells. The porous-pot form of Leclanché cell is to be obtained in three sizes, known as pint-size, quart-size, and three-pint size. Of these the quart-size is most general; it is about 5¼ inches high, and the glass jar is about 3¾ inches each way. This cell may be purchased complete for 1*s.* 9*d.* It is usual to prepare the cell for use by two preliminary operations. The first is to coat the top rim of the glass jar while hot with paraffin wax, or else with some bituminous preparation, in order to lessen the tendency of the liquid to *creep* and leave, on evaporation, a crust of crystals on the edge. The second process is to clean the rod of zinc by *amalgamating* its surface with quicksilver, as already described. This is advisable, but not absolutely necessary; but a dirty or impure rod is liable to consume away irregularly, owing to local corrosion.

The exciting liquid of the Leclanché cell, a solution in water of sal ammoniac (also called chemically ammonium chloride) is readily made by dissolving in warm water crystals of this substance, which can be bought of any druggist. But it is better to procure the crystals from the firms which supply the cells, as they will furnish sal ammoniac guaranteed to be free from lead salts, which are detrimental to the working of the cell. From three to four ounces of crystals will suffice for a cell of quart-size, and will give a saturated solution. After the liquid has been poured into the cell a few hours will elapse before the cell is in full working order, as it takes times for the liquid to percolate fully through the porous pot.

Cells once set up, and used for intermittent work, such as ringing electric bells, will last for months or years, needing little attention except occasionally pouring in a little water to replace that which has evaporated. It is also well to clear out from the bottom of the outer pot once every six months any sediment that may have settled there, and to add a few crystals of sal ammoniac. The zincs also are benefited by being scraped clean.

In places where a large number of cells are set up in series, as in testing laboratories, great importance must be attached to the insulation of one cell from another. In such a case as this the cells are set up in sets of ten in wooden trays, each tray being separately mounted on glass insulators.

Anode and Kathode. To distinguish between the two plates or *electrodes* of a cell, the name *anode* (which means way-in) is given to that plate or rod by means of which the current enters the liquid; while the name *kathode* (meaning way-out or way-down) is given to that plate or rod by which the current leaves the liquid to go to the circuit. In ordinary cells the anode is always zinc. Anodes dissolve: in fact, it is their solution which furnishes the energy of the current. Kathodes are not attacked: on the contrary, they usually receive a deposit, in some cases of metal, in other cases of hydrogen gas, unless surrounded by a depolarizing material.

As all cells are not equally good it is needful for the student to know how to test them. Tests are needed to ascertain two things: (1) the value of the electromotive-force of the cell, (2) the amount of current it can give. In other words, it is desirable to test the *volts* and the *amperes.*

Testing Cells. To test the electromotive-force of a cell there is needed a low-reading *voltmeter* [see page 292], graduated to read from 0·5 volts to 2·5 volts. It is applied to the cell by two wires when the cell is on *open circuit*, that is, when the cell is disconnected from the circuit and is giving no current. A Leclanché cell should show from 1·45 to 1·4 volts when in good condition as new; but after running for some time and getting spent it may show an electromotive-force as low as 1·2 volts or even lower. A Daniell's cell will show about 1·1 volts; a Fuller cell about 1·8 or 1·9. If no suitable voltmeter is available a good electric bell, if its coils are wound with very fine wire, may be used to test the cells; any cell which has a low electromotive-force will ring the bell feebly compared with a cell of higher voltage.

It is quite possible for two cells that are both alike as to their electromotive-force to give unequal currents, because, though the effort in each of them may be equal, if one of them offers a higher internal resistance to the flow of current than the other one does, it cannot yield as many amperes. If the porous pot in a cell is not porous enough the cell may be found almost incapable of giving a good current, and yet the chemicals in it may be all right and its voltage up to the right value. To test the number of amperes that a cell can give there is needed an *amperemeter* [see 3, page 292].

Fuller's Bichromate Cell. This is a more powerful cell than the Leclanché, but is more costly, and contains corrosive acids. As before, the material which serves as fuel is zinc. A solid rod of zinc stands [13] in an inner porous cell containing dilute sulphuric acid as excitant. Into this inner cell are also poured two ounces of quicksilver to keep the zinc surface bright, and prevent wasteful *local action.* In the outer pot, which is of quart size, stands the plate of carbon, and around it are poured four ounces of crystals of bichromate of potash (a powerful depolarizer), and four ounces of sulphuric acid, and then it is filled up with water. This cell has an electromotive-force of 1·9 volts.

In an earlier and very similar cell invented by Grove the depolarizer was nitric acid, and he used a platinum plate where in modern cells we should use the cheaper carbon.

Daniell's Cell. A cell of very constant properties is that invented by Daniell. It depends on the property that there will be no polarization—that is, no counter electromotive-force due to hydrogen films—if the metal plate is immersed in a suitable solution of a salt of the same metal. To attain this the copper plate is immersed in a solution of the blue

crystals of sulphate of copper, and the zinc dips into a solution of sulphate of zinc.

The sulphate of zinc solution acts as excitant, the sulphate of copper as a depolarizer. To prevent the two liquids from mixing they must be separated by a porous pot. Figure **14** illustrates one of many different forms of Daniell's cells, which are sometimes made narrow, so that a whole battery of them can stand compactly in a row in a tray. The zinc should be amalgamated with quicksilver to keep it bright. It slowly dissolves when the cell is giving out a current, and copper is slowly deposited on the copper plate by the current which decomposes the sulphate of copper in the solution. In **14** are shown a quantity of crystals lying in the bottom of the cell. The reason for putting these there is that they may act as a reserve: they will gradually dissolve as the copper in the blue liquid is deposited on the copper kathode. The electromotive-force of a Daniell's cell is usually about 1·1 volts.

Dry Cells. In recent years cells have been introduced under this name; but they should be called unspillable rather than dry, because they will not work unless they are moist inside. They are all modifications of the Leclanché cell, having zinc as the anode and carbon as the kathode. Figure **15** gives a section of the most common variety invented by Hitchcock. In this cell there are two pulpy or plastic layers touching one another. A white one next the zinc contains chiefly plaster of Paris with sal ammoniac as an excitant, and a black one next the carbon contains finely-powdered carbon and black oxide of manganese. Some hygroscopic material such as chloride of zinc is added to keep these layers moist. The cell is closed at the mouth with a layer of pitch, leaving a small vent-hole to permit the escape of gas bubbles.

The Cell as a Source of Energy. The consumption of the zinc furnishes the energy which the cell gives out. We have seen already that electric power is always made up of two factors—the effort-factor, which in this case is the electromotive-force of the cell, and the quantity-factor, which is the current that is drawn fromthe cell.

The electromotive-force depends solely on the chemicals that are used in the cell; thus in the Daniell cell, where we have zinc working against copper, the nett electromotive-force is 1·1 volts; but in the Leclanché cell, where we have zinc working against black oxide of manganese, the nett electromotive-force is about 1·45 volts. The current given out by any cell depends (as we shall see in the chapter on the ELECTRIC CIRCUIT) not only upon the electromotive-force of the cell, but also upon both its resistance and the other resistances in the circuit.

The larger a cell is, the larger will be the metal surfaces which come into working, and the less will be the internal resistance which the liquids inside offer to the flow of the current from one metal plate to the other. If the resistances, both that inside and those of the outer circuit, are kept small, then the current that flows from the cell will be large. The power given out by the cell at any moment will, as explained in Article 2, be the product of the number of volts of the cell into the number of amperes that are being drawn from it. Thus, if we are drawing 6 *amperes* from a Leclanché cell, of which the electromotive-force is 1·45 *volts*, the number of volt-amperes, or *watts*, with which it is working will be 1·45 times 6, that is, 8·7 *watts*.

Energy from Primary Batteries. Now from this we can calculate the cost of getting energy from primary batteries. Let us remember that 1000 volt-amperes for one hour are one Board of Trade unit Hence, if we were using a cell that had an electromotive-force of one volt we should get from it one unit of energy if it gave one ampere for 1000 hours. Now, experiment shows that in any cell where zinc is used the amount of zinc consumed usefully (leaving waste by local action out of account) is 2·66 lb. for every 1000 ampere-hours. But if we had a cell working with a bigger electromotive-force, we should get our unit of energy with a smaller number of ampere-hours. Thus, if we could use a cell of two volts electromotive-force, it would give us a unit of energy with only 500 ampere-hours of current, or a consumption of only 1·33 lb. of zinc. Hence to calculate the quantity of zinc needed in any cell in generating one unit of energy, we must take 2·66 and divide it by the number of volts at which the cell works. The corresponding numbers of pounds of other materials consumed are: sulphuric acid, 3·99 lb.; sal ammoniac, 4·18 lb.; bichromate of potash, 4·1 lb.; oxide of manganese, 7·13 lb. In the Daniell's cell the corresponding quantity of copper deposited is 2·57 lb.

Cost of Electric Energy from Cells. Let us then calculate the cost of one unit of electric energy if given by a battery of Leclanché cells. Let us put the prices as zinc, 3½*d.* per lb.; sal ammoniac, 5*d.* per lb.; oxide of manganese, 2*d.* per lb. Then we shall use of zinc, $2·66 \div 1·45 = 1·83$ lb.; of sal ammoniac, $4·18 \div 1·45 = 3·38$ lb.; of oxide of manganese, $7·13 \div 1·45 = 4·9$ lb. The costs will be zinc, 6½*d.*; sal ammoniac, 17*d.*; oxide of manganese, 9¾*d.*; *total*, 2*s.* 9¼*d.* And this is for one Board of Trade unit, for which the electric lighting companies may not charge more than 8*d.*, and of which the usual supply price is now generally less than 4*d.* Clearly Leclanché batteries will never compete with dynamos in the supply of electric light.

In the case of a battery of Daniell's cells, the weights are: zinc, $2·66 \div 1·1 = 2·42$ lb.; sulphate of copper, $6·5 \div 1·1 = 5·91$ lb.; and the deposited copper $2·57 + 1·1 = 2·33$ lb. The zinc will cost 8¾*d.*; the sulphate of copper at 2*d.* per lb. will cost 11¾*d.*; together 1*s.* 8½*d.*, but from this we must deduct 5*d.* for the copper deposited from solution, so that the nett cost of one unit, if furnished by a battery of Daniell cells, would be 1*s.* 3½*d.* Even if a cell could be found that would work at 2½ volts, the cost of zinc alone (to say nothing of acids, maintenance, supervision and standing charges) would be over 3½*d.* per unit, so that no primary battery using zinc will be able to compete with the electric lighting stations in the public supply of electricity.

To be continued

OBJECT DRAWING, WITH PRACTICAL GEOMETRY

A First Practical Lesson in Object Drawing, Cube and Square Prism. Lines, Angles, and Proportionals in Geometry

By WILLIAM R. COPE

Drawing a Simple Group. We shall now explain the method of drawing a simple group as shown in 67. The student must obtain *real objects* from which to draw, and ought not to copy 67, for he ought now to learn to draw from the "round." A box and a rectangular sheet of paper will serve as models. Place them upon a table at a distance of eight or ten feet away, so that the top of the cube or box is somewhat below the eye level. The objects need not necessarily be exactly of the same proportions as in 67. The drawing should nearly fill a piece of paper not smaller than quarter imperial (15 in. by 11 in.), and larger paper will be required later. When an artist commences a sketch of a landscape he determines where the four boundaries of his picture and the position of the horizontal line will come in the scene before him. The latter can be ascertained by holding a stiff piece of cardboard horizontally, etc., as previously explained, and the boundaries by cutting in the cardboard a rectangular opening of the *same proportion* as the canvas or paper—*e.g.*, if the canvas be 15 in. by 12 in., the opening should be 5 in. by 4 in., then, holding the cardboard vertically and adjusting its distance from the eye, the four edges of the opening will show which objects of the scene will come just on the boundaries of the picture. The same method may be used with the cube and board [68], and more especially as a test, after judgment with the eye alone, of the proportions of the objects and the various directions of their edges.

The right and left-hand boundaries of the group [67] are the imaginary vertical lines *QP* through *B* and *NO* through *D*. These two vertical lines should be drawn first, about an inch from the edges of the drawing-paper, which ensures the paper being fairly well filled with the drawing, and also determines the scale of the latter.

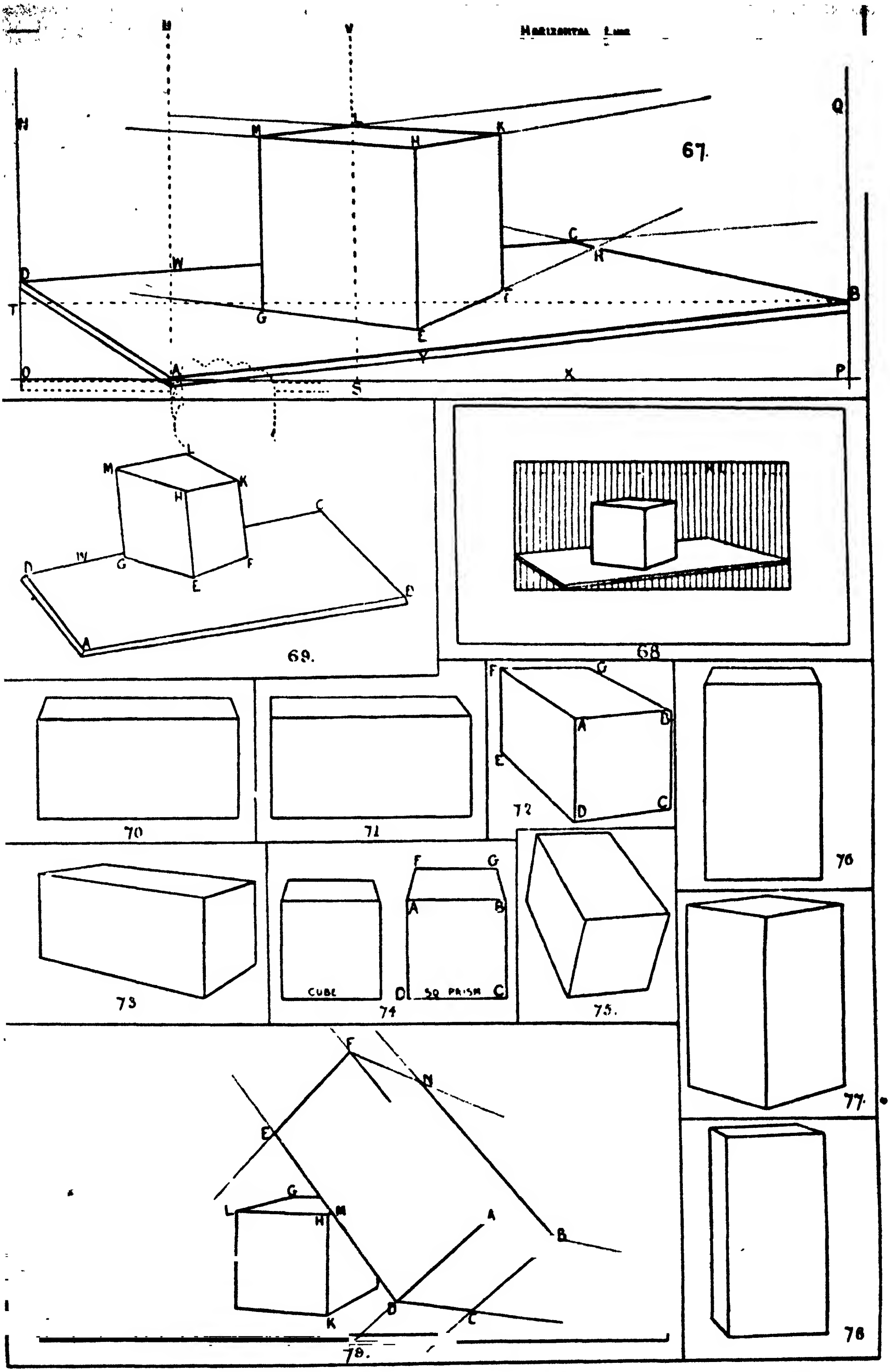
Importance of True Proportion. All representations of masses, edges, etc., must henceforth be kept in true proportion with this scale. Now make a few preliminary, but careful and searching observations of the general proportions—*e.g.* the width *OP* or *TB* of the group is about three and a third times the height *LS*; the vertical edge *EH* is very nearly equidistant from the corners *D* and *B*; the edge *GM* about midway between the corner *D* and the edge *FK*; and the corner *A* is much nearer to the left-hand side of the group than to the right. All these measurements are of course only as they seem to the eye from the point of observation; they are the *apparent* not the *real* distances.

The student must assiduously persevere in making these and every judgment first with the eye alone, and afterwards test by measuring with the pencil held as already advised. The mind being stored with these important facts, the exact position of the corner *A* should be observed by comparing the distance *OA* with *AP*. It will be found that *AP* is about four and a half times *OA*. In testing this the ascertained length *OA* should be carefully stepped along *AP*, and it is most important that the pencil should be held correctly, (see dotted line drawing of hand and pencil in 67), *not* slanting away because the edge recedes.

The Three Most Important Points. The position of *A* should now be marked on the drawing paper, by making the space between it and *QP* four and a half times that between it and *NO*. Do not use the cumbersome and unsatisfactory method (which does not train the eye) of taking a measurement from the objects and then some multiple of it to suit the scale of the drawing. Next obtain the slope of the edges *AB* and *AD*, by observing that the corner *B* is *apparently* slightly lower than *D*, the apparent size of the space between *O*—level with *A*—and *D* is two-twirds of *OA*, and that *PB* is about one-fifth less than *OD* or a little more than one half of *OA*. To test, hold the pencil *vertically* to obtain apparent length of *OD* and *PB*, and *horizontally* to compare them with *OA*. Then mark these positions on the respective vertical lines in the drawing, in the same proportion with *OA* already obtained, and the three most important points are thus determined.

Now fix the position of the *horizontal line* by comparing the distance *AU* with *AP*, and as a check *LV* with *AO*. Then draw the lines *AB* and *AD*; these, if continued to the line *HL* extended, would give their respective vanishing points, which are, as in 67, very often outside the limits of the drawing-paper, but with care their position may be judged. Afterwards draw *DC* very slightly converging with *AB*, and *BC* more quickly with *AD*. The larger the angle at which parallel edges recede the more quickly they appear to converge, as *AD*, *BC*; and the more nearly they appear horizontal, as *AB*, *CD*, the less quickly they converge. The intersection of *BC* with *DC* gives the position of *C*.

Next apply a few tests to the drawing, as any inaccuracy not corrected at this stage will cause great trouble when drawing the cube. For instance, test by holding the pencil vertically, whether the distance *AW* from the front corner to the back edge is in true proportion with *AO*, not as in 69; and that the back corner *C* is opposite a point on the front edge, so that *XP* is two-fifths of *AP*, or two-thirds of *AX*. Then sketch the lines to show the thickness of the



A FIRST LESSON IN OBJECT DRAWING. DIFFERENT VIEWS OF THE SQUARE PRISM

board, and keep the very short lines at the corners *vertical*, not as in **69**.

Drawing the Cube. In drawing the cube, first determine the position of the corner *E*, by comparing the space between *D* and *E* with that between *E* and *B*, or *AE* with *AD*, or *AE* with *EB*. *E* is much nearer to the front edge at *Y* than it is to the back, and is nearly equidistant from *D* and *B*. In **69** the position of *E* is quite wrong. Now draw the lines *EF* and *EG*. The board being correctly drawn, it is quite easy to determine the *direction* of the two edges which they represent, for it will be noticed that *EF* recedes towards a point *R* not far from the corner *C*, and *EG* directly towards the corner *D*. Next ascertain the *apparent* length of *EF*, which is about equal to the distance *FC*, and of *EG*, which is about two-thirds of *GD*. Then draw a vertical line through each of the points *G*, *E*, and *F*, also observe that *EH* is *apparently* rather longer than *EG*. The height of *GM* and *FK* can easily be settled by drawing *HM* converging with *EG*, and *HK* with *EF*, to their respective vanishing points. From *M* draw *ML* converging with *HK* and *EF*, and from *K* draw *KL* converging with *HM* and *EG*, thus obtaining the apparent shape of the top surface. Do not be afraid of producing these lines some distance right and left, as in **67**, in order to see whether they are converging properly. Now hold the drawing vertically at arm's length, compare it carefully with the group of objects, correct any inaccuracies, clean up, and finish with a soft, broad, grey line.

The Secret of True Drawing. The secret of making a true drawing lies in the most careful and searching observation of the proportions between various spaces, and the proper convergence of lines which represent what are really parallel edges. Do not be satisfied with a comparison between one part and *one* other, but make it between one part and *several* others. The mistakes generally made are such as are shown in **69**, where, besides those already mentioned, *AB* and *DC* are diverging instead of converging towards the right, and *AD*, *BC* do not converge to the left, thus causing the board to appear warped and wider at the right end. The edges *EF*, *HK*, are converging towards the right, but *ML* is not; also *EG*, *HM*, *KL*, are not converging towards the left, while *GM*, *EH*, *FK* ought to be vertical. If the invisible back edges were represented it would be seen that the back corners of the cube would appear to be beyond the back edge of the board. The space *DG* is too small, *AD* is too long and slanting in the wrong direction. The point *A* is too far to the left. There are other errors which an observant eye will easily detect.

The Square Prism. In **70** to **78** we give various appearances of the square prism, an object which is square at its ends, and has an oblong for each of its four side surfaces. The method of drawing this is similar to that of the cube, but special attention should be given to the fore-shortening of the long edges in particular views, as in **72** and **74**, where the long edges *AF*, *BG*, *DE*, are represented by shorter lines than *AB*, *BC*, *CD*, *DA*, those for the short edges. Compare the drawing of the cube with that of the square prism in **74**; both are views seen when the spectator is directly opposite the square surface, but the objects are below the eye level.

Figure **75** represents the prism resting on one of its short edges. In **79** we have a more difficult view of the prism resting on one of its corners on the board, and its under surface leaning against one top edge of the cube. The board and cube will give little trouble to draw, but observe that the front and back edges of the board do not converge, because they are not receding from the observer, while the side edges do so rapidly. In this case we have the two extremes, one where apparent convergence takes place most rapidly and the other where there is no convergence at all. The student should place the objects as indicated, and observe that the edges *AB*, *DC*, *FN* are apparently converging downwards to the right, *AD*, *BC*, *FE* downwards to the left, and *AF*, *BN*, *DE* upwards to the left. Even without a knowledge of advanced perspective the position of each set's vanishing point can be determined, if careful attention be given to the apparent direction of any two edges in each set.

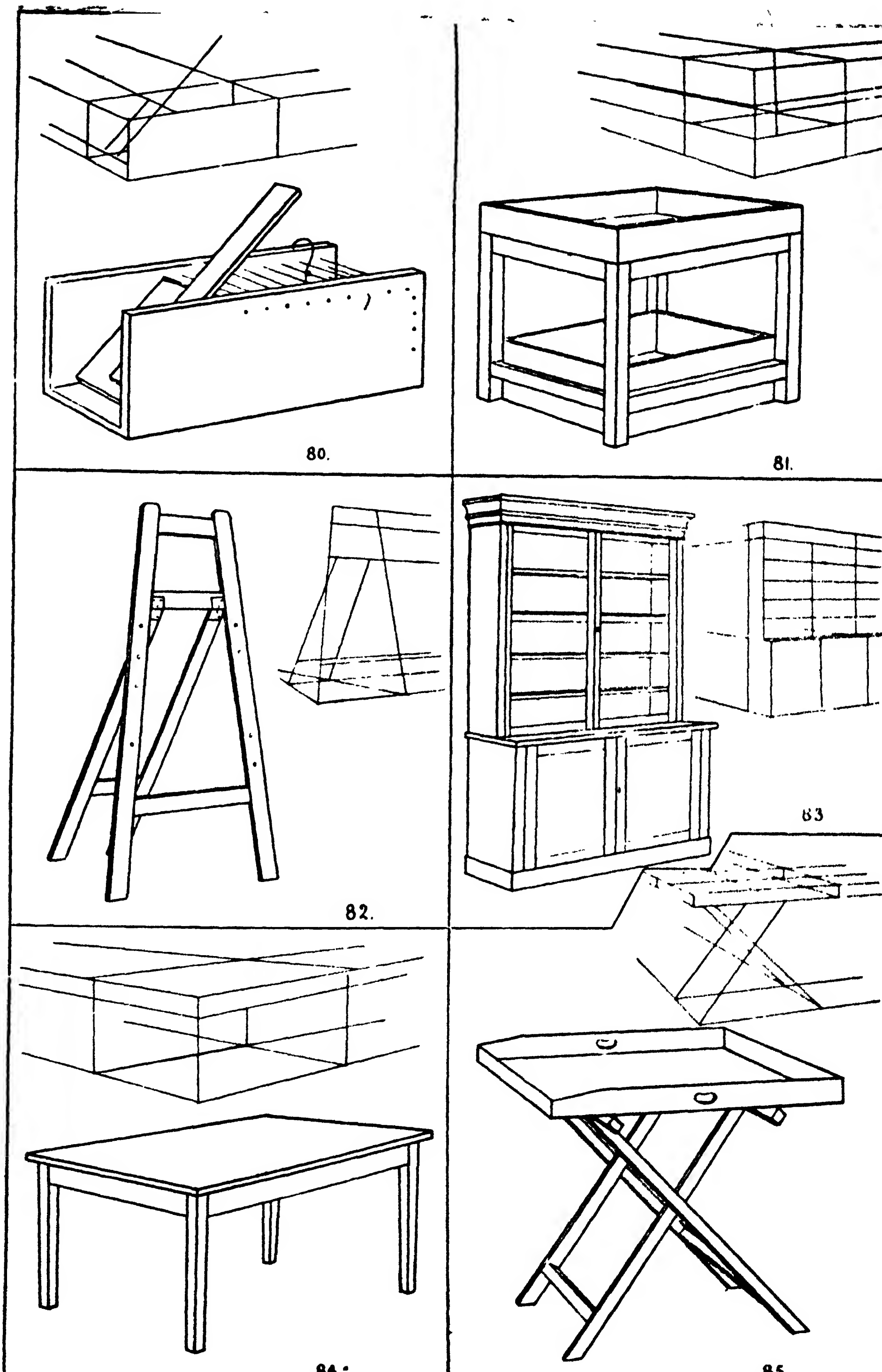
Drawing the Prism. Assuming that the board and cube are drawn, begin the drawing of the prism by obtaining the position of the corner *A*, and next the slant and length of the three edges *AB*, *AD*, *AF*, each of which belongs to a different set. Notice that *D* is rather higher than *K*, and *KD* is about two-thirds of *KH*; *AB* is three-fifths of *AD*; while *AF* is three times as long as *AB*; and the corner *C* is almost vertically under *A* and level with *K*, thus determining the direction of *BC* and *DC*. The point *E* is to the left of *G*, but higher, and the distance *EG* is equal to *KD*, which gives the direction of *FE* and *DE*. The direction of *DE* could be found by observing where it cuts the edge *HM* of the cube. Draw *FN* converging with *AB* and *DC*, and *BN* converging with *AF* and *DE*. Each set should converge as shown in **79**.

Having mastered these geometrical solids, the student should draw from objects similar in construction; such as rectangular boxes, bricks, books, stools, chairs, tables, doors, cupboards, steps, easels, tanks, and picture frames. Some of these are shown in **80** to **85**. He should analyse each object and endeavour to find some simple lines of construction; draw these first correct in proportion and perspective, as indicated by small sketches in **80** to **85**, the study of which will teach him much more than hundreds of words.

PRACTICAL GEOMETRY

Lines, Angles, and Proportionals. The following are preliminary exercises which will often be required in succeeding problems:

86. To Bisect a given Line *AB*. The best way is to do it by trial with the compasses. Another method, **86** *A* and *B*. With centre *A* and any radius longer than half the line describe an arc. With centre *B* and same radius intersect it in *C* and *D*. Draw *CD* which bisects the given line at right angles



EXAMPLES OF OBJECTS DRAWN ON THE SAME PRINCIPLES AS THE CUBE AND SQUARE PRISM

87. To Draw a Perpendicular to a given Line AC, from a given Point A within or B without the Line. This may be done in several ways by intersecting arcs, but the most practical, most accurate, and quickest is by *placing a ruler level with the line AC, and a set square with one of the edges exactly touching the ruler, and the other passing through the given point as shown in* **87**.

88. To Bisect a given Angle ABC. With centre B and any radius describe an arc to cut the lines in A and C. With centres A and C and any radius describe arcs to intersect in D. Draw BD which bisects the angle. By this means an angle may be divided into 4, 8, 16, etc., equal parts.

89. To Trisect a Right Angle ABC. With centre B and any radius describe the arc AC. With centres A and C and same radius cut the arc in D and E. Draw BD and BE which trisect the right angle.

90. To Draw a Line parallel to another AB, at a given Distance C from it, or through a Given Point D. At any point in AB draw a perpendicular GF equal to the distance C. Place one edge of a set square level with AB, then a ruler against another edge of the set square [**90**]. Hold the ruler firmly fixed, but slide the set square along it until the edge (which was level with AB) passes through F, and draw FE the required line. When the point as D is given, the method is the same except that no perpendicular is required [**90**].

91. To make an Angle Equal to a Given Angle ABC. Draw any line EF. With centre B and any radius describe the arc AC. With centre E and same radius describe the arc DF. With distance AC as radius and F as centre cut the arc in D. Draw ED through E and D (Euc. III. 27).

92. Through a Given Point C to Draw a Line meeting a Given Line AB at an Angle equal to a Given Angle H. Through C draw CF parallel to AB. At C make the angle FCD equal to H, and the angle CDB will also be equal to it (Euc. I. 29).

93. To Bisect the Angle made by Two Converging Lines BA, DC, without using the Apex. Draw a line at any convenient distance parallel to AB, and another at same distance parallel to CD to intersect in E. Bisect the angle thus obtained.

94. Through a Given Point E to Draw a Line converging to the Same Point at which Two other converging Lines would meet if Produced. Draw any two convenient lines FG, HK parallel to each other and cutting both AB and CD. Join E and F, E and G. Through H draw HL parallel to FE, and through K, KL parallel to GE, intersecting at L. Draw EL through E and L.

95. In a Given Line AB to find a Point Equidistant from Two Given Points C and D without it. Join C and D, and bisect the line CD by a perpendicular meeting AB in E, which is the required point.

96. To Draw Two Straight Lines to Meet a Given Line CD from Two Given Points A and B without it, and to Make Equal Angles with it. Draw AE perpendicular to CD so that FE equals FA. Draw BE cutting CD in G. Draw AG. Then AG and BG are the required lines.

Proportionals. If a straight line be drawn parallel to one side of a triangle, it cuts the other two sides or those produced proportionally. (Euc. VI. 2).

97. To Divide a Line AB into any Number of Equal Parts (say Seven). Draw AC at any angle with AB, and set off on it any convenient distance seven times. Join $7B$ and from the points 6, 5, 4, 3, 2, 1, draw parallels to $7B$ to cut AB.

98. To Divide a Line AB proportionally to a Given Line CD. Draw AE at any angle with AB. Make $A1$, 1 2, 2 3, $3E$ equal to $C1$, 1 2, 2 3, $3D$ respectively. Join E and B. Draw parallels to EB through 3, 2 and 1 to meet AB.

99. To Divide a Given Line AB in the Same Proportion as the Nos. 3, 5, and 2. Draw AC at any angle with AB, and set off on it 3 + 5 + 2 equal parts. Join 10 and B, and through 3 and 8 draw parallels to $10B$ to meet AB. Then $AD : DE : EB$ are as 3 : 5 : 2.

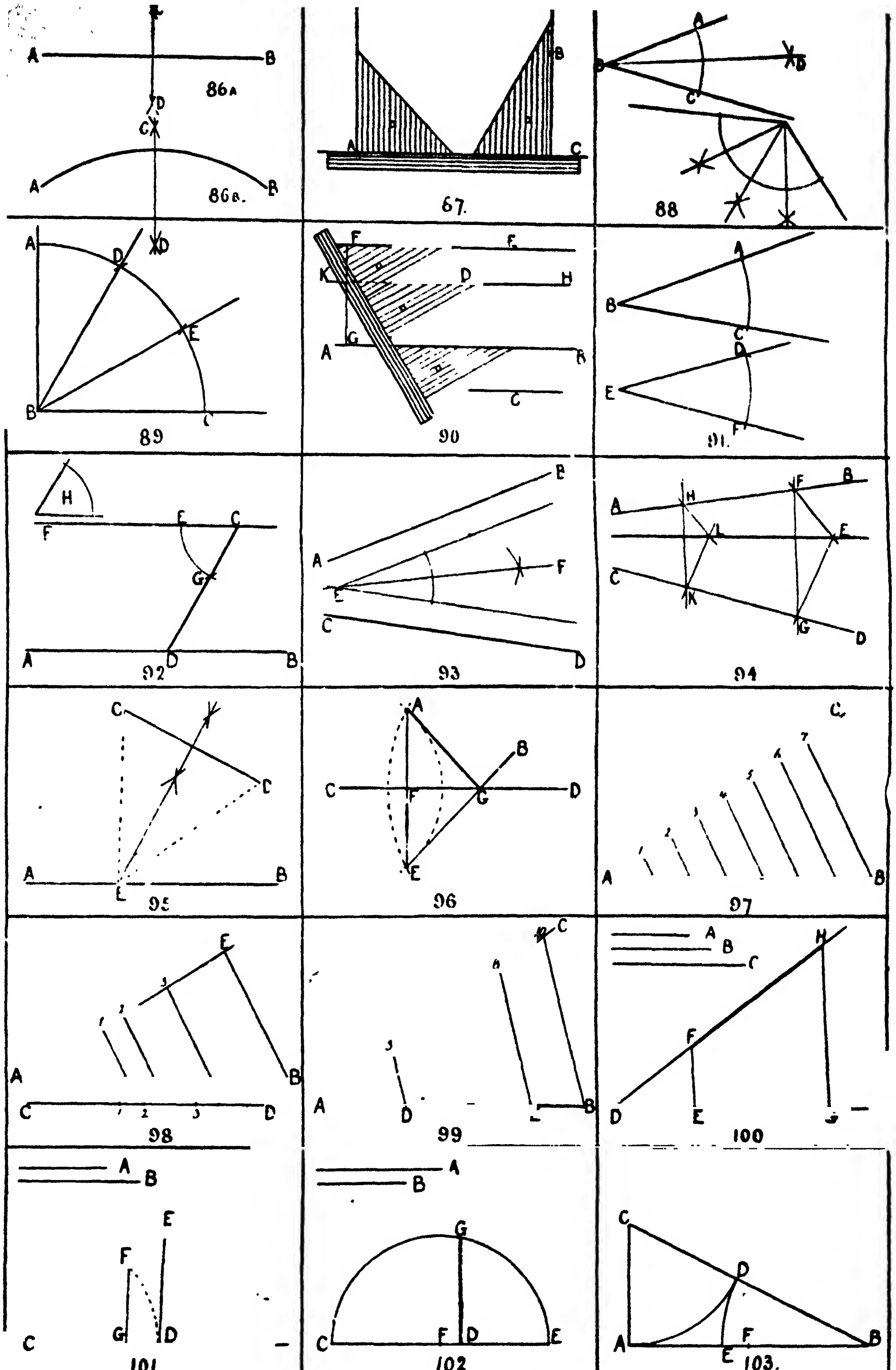
100. To Find a Fourth Proportional (Greater or Less) to Three Given Lines A, B, and C. Draw DG and, at any angle with it, DH. Set off DE equal to A, and DF equal to B. Join E and F. Set off EG equal to C. Through G draw GH parallel to EF cutting DH in H, then FH is the fourth proportional *greater*—*i.e.*, $DE : DF :: EG : FH$. When the fourth proportional *less* is required, use the same method, but commence with the *longest* line.

101. To Find a Third Proportional (Greater or Less) to Two Given Lines A and B. This is the same as finding the fourth proportional to three given lines, the last two of which are equal (*e.g.*, $A : B :: B :$ required line). Proceed as in **100**, but remember B is used twice (in **101**, CF and CD each equal B). CE is the required third proportional *greater*. For the third proportional *less*, commence with B and use A twice.

102. To Find a Mean Proportional to two Given Lines A and B. On a straight line make CD equal to A, and DE equal to B. Bisect the whole line CE in F and describe a semicircle with F as centre and FC or FE as radius. At D draw DG perpendicular to CE to meet the arc in G. Then DG is the mean proportional—*i.e.*, $CD : DG :: DG : DE$, or $A : DG :: DG : B$.

103. To Divide a Line AB into an Extreme and Mean Ratio—*i.e.*, so that one part shall be a mean proportional between the whole line and the other part. Draw AC perpendicular to AB and equal to half of it (AF or FB). Join B and C. Make CD equal to CA. With centre B and radius BD cut off BE. Then AB is divided at E so that $AE : EB :: EB : AB$, or so that the rectangle AE, AB, equals the square on EB (Euc. VI. 30 and II. 11).

To be continued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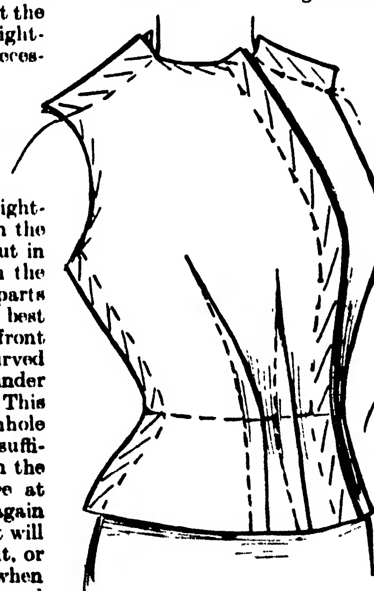
BODICE FITTING & EVOLUTION OF THE BLOUSE

The Fitting and Making of a Bodice. Alterations. Pressing. Sleeves and Collar. The Drafting of Various Blouses from Bodice Pattern

By AZELINE LEWIS

Fitting and Making Up. Before fitting on the bodice, the seams of the back and curved side pieces must be notched at the waist, also an inch above and below the waist-line; the under-arm seams and the darts should not be notched until the bodice has been tried on [28].

Put on the bodice with the seams outside and pull it down into the waist at the back, then pin the front fitting lines together at the waist, bust, and neck lines [29]. See that the waist-line sets well into the curve of the waist. If the armhole feels too tight, be careful not to hollow it out hastily. This point cannot be insisted on too strongly at the very outset, as it is a very common mistake with amateurs, and even with so-called "little" dressmakers, to slope out the armhole at the first suggestion of any tightness. Ascertain the necessary alterations *before* touching the armhole, for, if once cut out too much, a mistake has been made which often results in ruining the bodice. Very often the tightness may be remedied in the course of the fitting, but in any case do not touch the armhole till the other parts have been fitted. The best plan is to snip it at the front to within ½ inch of the curved line, and if too high under the arm, snip here also. This will increase the armhole considerably, and allow sufficient seam for sewing in the sleeve. Lift the bodice at the front waist and again pull the back down, or it will appear too long in front, or too short at the back, when the fronts are finally pinned together. Now bring the waist lines together, pin there and below, pin the front fitting line from the bust downwards, once or twice lifting the bodice at the neck, and putting the hand inside; gently press the bust up, that it may fall into its proper shape, then pin up from the bust line to the neck.

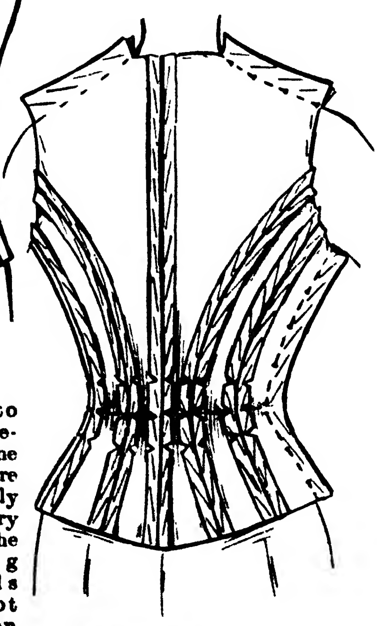


29. FITTING ON FRONT

Alterations. When this is done, the fitting of the outlines should be carefully looked over, to see that the waist-line at the back fits into the hollow of the waist, that the width of back from shoulder to shoulder is sufficient, that the under arm is the right length, and that the curved side pieces sit well into the hollow of the waist and close under the arms.

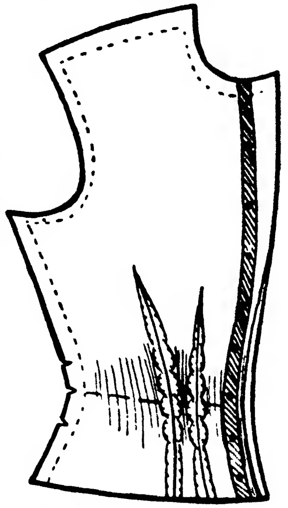
Should the bodice be too short-waisted, let it down at the shoulder seams, taking care that sufficient turning is left for the armhole; if it is too long-waisted, take it up at the shoulders, and hollow it out at the back of the arms. The neck must be altered according to the alterations made, that is, either taken in or let out as far as the bust line. Any other alterations are made at straight under arm seams and shoulder seams, leaving the curved side seams and the darts untouched. For instance, if the waist be a little large, it must be taken in at the side seams, and if the fronts or backs be too long they must be lengthened or decreased from the shoulder seams.

To Make Up. If the fit is satisfactory, take the fronts from the other portion of the bodice, as the required fastenings are easier to put on than when joined together, and see that both sides are exactly alike. The seams should be machined just outside the wheel-marks in order that the tacking threads may be more easily removed. This can be done without injury to the material if the threads are previously cut every ½ inch. The basting threads must not be taken out until



28. FITTING ON BACK

the bodice is finished. Before overcasting the seams cut all frayed edges even, round off the notches, cut at the waist line, leaving ¼ inch turnings, and cut and curve the other seams to correspond. Cut the darts to within ½ inch of the top, leaving ⅜ inch turnings on each side; notch and curve these, then overcast the seams and darts with either silk or cotton of a contrasting colour. This stitch should be worked loosely, as, if pulled up too tightly, it will form a hard ridge, and show through the material when the dress is on. The overcasting stitch is used not only to neaten, but to prevent fraying, and if very "frayey" materials be used, the stitch must be taken down a little deeper.

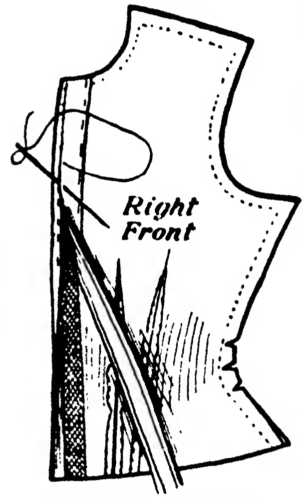


31. LEFT FRONT WITH BUTTONS

Finishing the Darts. The darts require very careful finishing, as the tip of these should melt off at the top as though they were woven in the material. To do this, slope off the line of machine stitching at the "head" or top to a point, then thread the end left (which should be fairly long) on a needle, and finish off with a few stitches of oversewing.

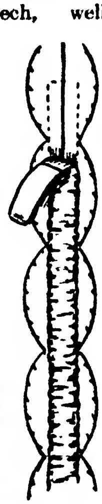
Pressing the Seams. The seams must be pressed on a rounded surface; the rail of a towel-roller, or a long rolling-pin of ash or beech, answers the purpose well, but it should be covered before using. Both sides of each seam must be smoothed with a warm iron. Dip the finger into water, open the seams, and run them lightly along, next press with a hot iron; do this with a firm, gentle pressure, but on no account rub or force the iron along, taking care not to stretch the length of the seams. The tops of the darts should be pressed quite flat, care being taken that here again the bodice is not stretched. The bodice is now ready for the fastenings—either buttons and buttonholes, edge to edge fastenings, or hooks and bars.

Preparation for Dressmakers' Buttonholes. Should buttons and buttonholes be required, the preparation is as follows. Take the right front of bodice and turn the edge in ½ inch from the front fitting line, mark with white cotton; now mark another ½ inch beyond the white cotton on the wrap, cut the rest of the wrap away, turn down and press. Take a strip of tailor's linen or waistcoat canvas, 1½ inches wide, put the raw edge of this strip to the fold of the turn-down, this should be basted to the front twice, holding the front of the bodice well over the hand while basting. Now tack the ½ inch turn-down to the linen. To face the right side of bodice, use a piece of the material or fine Italian cloth 2 inches wide; this wears much better than silk or sarcenet [30]. Turn down the edges of the facing ½ inch on either side and press, this also should be basted down twice on the front, just inside the edge of the bodice (holding the front of bodice well over the hand), then felled down on both sides with a fine needle and silk. This side should be well pressed before beginning the buttonholes, for the working of which see BUTTONHOLES (Part I.) For the button-side see diagram 31, also Part I., where the method of sewing on the buttons is fully explained.



30. FACING FRONT FOR BUTTONHOLES

Fastenings. To strengthen the front for edge to edge fastenings with hooks and eyes, take a strip of linen or lining on the straight, 1 inch wide, tack near the fitting line and again at the other edge, keeping the front of the bodice well over the hand to prevent tightening, cut off the wrap to within ½ inch of the fitting line, turn it down and well press. Machine close to the very edge of the bodice, right up to the top. Now tack, with very small stitches, the linen and lining together ½ inch from the front fitting line, as high as the top of the dart, to form a casing for the edge bone, taking care that the stitches do not go through the material. Fell down the ½ inch wrap to the linen, not taking the stitches through, then fell the outside edge of the strip of linen to the lining, still taking care that the stitches do not go through. Insert the edge bone (a narrow whalebone, ¼ inch wide, the same length as the dart) and fasten the bone securely top and bottom. Treat the left side of the bodice in the same way. The fronts are now ready for the hooks and eyes.

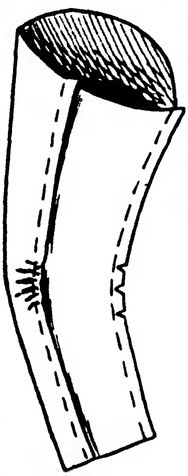


32. BONE CASINGS

To Put on Hooks and Eyes. Measure the distance for the hooks and eyes very carefully, beginning at the waist line and allowing ¾ inch between each. Begin to sew them on at the waist line, a hook and eye alternately, the hooks

being sewn ¼ inch in and the eyes level with the edge to make it fit closely.

How to sew them on is dealt with in PART I. Do not be afraid to put a few extra stitches in each hook and eye, as there is great strain between the waist and the bust, and unless sewn on firmly they will pull away, causing great annoyance and necessitating double work to replace them. The hooks and eyes will be faced after the basque has been turned up. Having arranged the fastenings, join the fronts to the other portions of the bodice; machine the under-arm and shoulder seams, notching them above and below waist. Neaten, overcast, and press in the same manner as the other seams, and complete the casings. The bodice is now ready for turning up the basque.

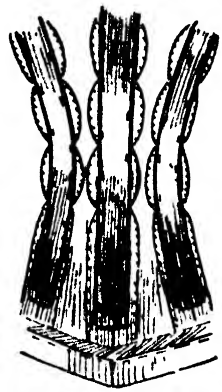


34. SLEEVE READY FOR STITCHING

Turning up the Basque. Before turning up see to the fit where the basque is shaped, and tack a strip of linen or canvas (according to material used for dress), 1 or 1½ inches wide, cut on the cross, round the edge of the basque. Turn up the bodice and tack very firmly, roughly sewing the raw edge to the lining over the canvas or linen. Be sure the stitches do not go through. Carefully mitre the corners of the bodice, as for collar, and well press.

35. FACING WRIST BAND

Facing the Hooks and Eyes. Cut a piece of the material (if thin enough) of fine Italian cloth on the cross, 1½ inches wide, allowing ¼ inch turnings on each side; turn this down and well press. Begin at the top of the neck (the right side), placing the facing well under the bill of the hook, baste it round the bodice and basque, holding it well over the hand, cutting away the folds under the corners of the bodice. Ease the facing there, or the corners of the bodice will turn up; also ease well at the centre of the back. Then baste it up to the left side of the neck, and neatly fell all round and on both sides with silk the same colour, keeping the stitches loose, and being careful not to take them through.



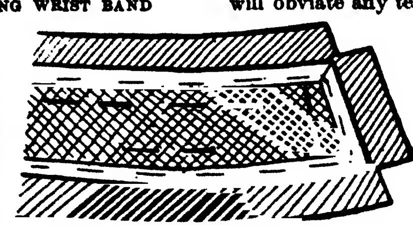
33. STEELS AT BACK OF BODICE

The wrap is a strip of material 2½ inches wide. Turn in ¼ inch on each side, fold and press, and either machine or slip-stitch turnings of ends and long edge. Place the fold on the hooks and eyes on the left side of the bodice, and secure with buttonhole stitch several times. Thick cloth is cut single 1½ inches wide, and the edges are either bound, pinked or overcast. The wrap only comes just a little distance below the waist.

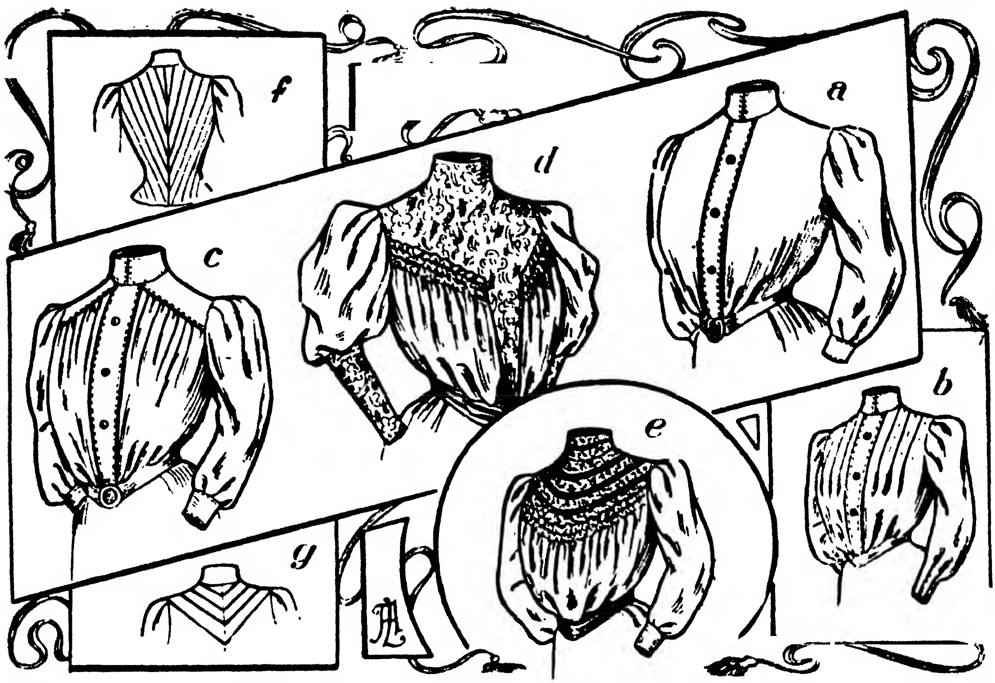
The stiffenings required for the seams must now be put in, and as these may be either bones or steels, we will describe the method of putting in both. There can be no doubt that whalebone is much better for the purpose than steels, but as it and its substitute, feather bone, are both somewhat expensive, and steels have the advantage of greater cheapness and simplicity of working, the latter are often preferred. We will take boning first.

The Bone Casings. Cut the galoon, or binding, into strips, 3 inches longer than the actual length for the seams, 3½ inches longer for the darts. Before running the galoon on the seams, gather slightly all the way down on either side, keeping the centre of the casings directly on the seams. Make the pockets for the darts from 1 to 1½ inches long, fell on one side, then fell or run the casing on the dart seam to within ¾ inch of the edge of basque, and up to the pocket. All the ends of the casings should be free [32].

When all the seams are cased, cut the whalebone (which should be soaked and put into the bodice while damp) the required length, ¾ inch longer than the casings. For the bones which will lie on the darts, the holes should be pierced from 1 to 1½ inches from the end; by this means the bone tops come even with the top of the dart seams, and the loose parts will obviate any tendency to force out the bodice at the bust. The bones for the under-arm seams should be 2½ inches down from the bust line, and the bones at the top of the other seams must be even with them. The holes for these bones are pierced ¾ inch from the top, and should also be left loose; the holes at the lower end of all the bones are pierced ¼ inch from the end. The holes for this purpose are



36. COLLAR



37. YOKE BLOUSES DRAFTED FROM BODICE PATTERN

easily made with a hot knitting needle. See that the ends are well rounded with a sharp penknife or file. Before putting the bones in, bend them well with the thumb and finger; but remember they are not put in until the basque has been turned up, when they are slipped into the casings, then the sides of the pockets are felled up, and the bone firmly fastened to the casing through the perforated holes. Finish off the ends with a fan stitch.

Covered Steels. Start at the centre back seam, pin the steel ½ inch from the turn-up of the basque. Measure the length of the steel on the bodice, and lower it ½ inch. Pin firmly, press the ½ inch well into the hollow of the waist, that is, 1¼ inches above and below the waist-line, pin there, and again between the waist and the top of the dart with fine pins. Begin to sew the steel ½ inch from the top of the seams and 1¼ inches from the top of the darts, leaving all ends free. Place the first stitch at the back of the steel under the seam, bring the needle out at the side of the steel, put the needle back at the same place, bring it out under the seam, this forms a back stitch; now put the needle in again 1 inch away from the last stitch, still at the back of the steel; make another back stitch, continue this on both sides of the steel, leaving the lower end loose ½ inch from the basque, using a double stitch at the waist [33].

Putting the Sleeves Together. In putting the sleeves together, always keep the largest side uppermost. Pin the elbow lines together and pin from the top of sleeve to the wrist; turn the sleeve round still with the larger part uppermost, and pin up from the wrist-line to the top of sleeve on the inner side. Now tack with small stitches from the top of the sleeve to elbow line, and from elbow to wrist, also from wrist to the top of the sleeve of the inner part. For the left sleeve reverse the process. The sleeves will then be ready for machining. Having done this, be sure to notch the inner seam an inch above and below the elbow line [34]. Round the notches, oversew neatly, and press on a roller. Cut a strip of muslin on the cross 1¼ inches wide, fold it, and place the fold on the wrist line, baste over the hand. Now tack the raw edge to the lining, and face with material of Italian cloth, cut on the cross, or to the shape of wrist; baste to sleeve, and fell with silk and fine needle, holding the sleeve well over the hand [35].

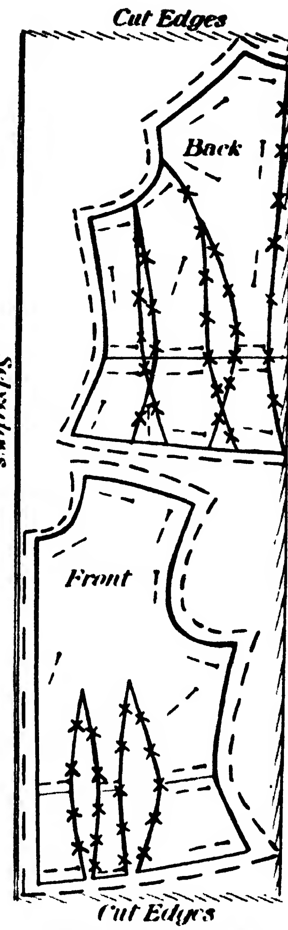
To Set in the Sleeve. Pin the front seam of the sleeve to the inset mark, and the back seam to the curved side-piece, within 2 inches of the shoulder seam. Pin the sleeve to the under part of the bodice, well easing it under the arm, and slightly easing it from the inset mark to 1½ inches above this. Next gather the top of the sleeve and distribute the gathers evenly between the inset mark and the curved side piece. Be sure to tack the sleeve in the wheel marks, and hold it towards you when putting in. Care spent on this part of the bodice is always repaid, as an imperfectly setting sleeve will spoil the whole effect.

Cutting and Making the Collar. Fold a piece of paper, and place the back of the pattern to the fold. Trace all round, excepting at the fold, not allowing turnings, remove the pattern and cut out the part traced. For the collar, about 3 inches of buckram or tailor's canvas will be required. Place the pattern on the canvas with the fold to a straight thread, and the fronts on the cross, and cut out. Next cut out two pieces of very thin lining or muslin, the same size as the canvas, place the latter between them, and tack all round the edge of the canvas. Now cut the material, allowing ½ inch all round for turnings. This should be herring-boned down to the top, bottom and sides of the canvas interlining, taking care to cut away the fold of the material that overlaps at the corner of the collar [36], snipping the top of the material to make it set flat along the curved upper side. Now press the inside of the collar with a hot iron as directed for sleeves.

Sew on the hooks and eyes alternately, the hook ½ inch from the end of the collar, and the eye just touching the edges, but not projecting beyond. If the material is very thin, it should be lined with lawn or muslin.

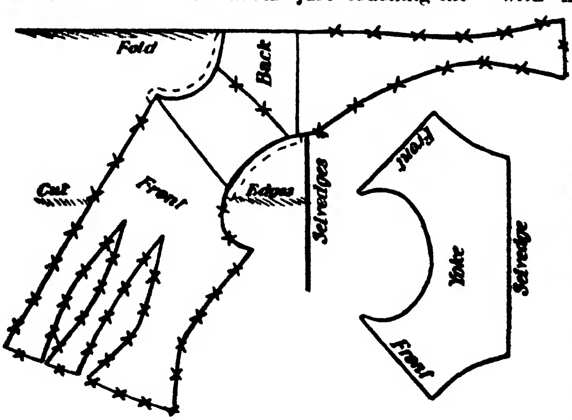
To Set on the Collar. Halve and quarter the collar, also the neck of the bodice; pin the centre of the collar to the back of the bodice, also pin the ends to the front fitting line; then hold the inside of the bodice towards you, having the collar and bodice well over the hand; pin the collar halfway between the pins, and again, midway between the other pins. After it has been well pinned, it should then be firmly stitched on from the inside, taking care to sew in the wheel marks. The collar should be faced with silk, sarcenet or lining, cut the same size as the material with ½ inch turnings, and felled neatly to it all round.

Putting on the Tight Band. Take a piece of webbing for a band, which should be ½ inch less than the waist measure after the ends are turned in. This is fastened with either one or two hooks and eyes. Before the band is adjusted, the skirt hooks are sewn to the casings of steels or bones on the three back seams, the bill of the hooks just touching the waist line. The webbing is slipped under the bill of the hook, with the centre of the webbing to the centre of the back seam of the waist. Now fasten the webbing to the bone casings of the bodice with a large cross stitch, with the same coloured silk as that used in overcasting the bodice seams.



38. A PLAIN BLOUSE

The Blouse. Dame Fashion, in spite of her changeableness, has remained faithful to the allurements of her old favourite, the blouse, and though frequent prophecies to the contrary have been made, it is still with us, and too firm a favourite to be ignored in a dress-making course. For this we credit the fickle lady with much good sense, although the blouse of to-day is a very different affair from its ancestress, the garment introduced by Garibaldi, and much worn somewhere in the sixties.



39. AN AMERICAN YOKE

It would be quite impossible to deal with the many guises assumed by the blouse, but from the following examples and explanations we hope a worker will see how easy it is to reduce the apparent intricacies of any model to its elements, and evolve almost any design she pleases. It may, however, be well to point out that whatever be the method of expression, whether the blouse be unlined or made up on a fitted lining, without or with a yoke, the latter either plain or tucked, of lace, of strips of material or insertion united by faggot-stitching, the underlying principle of all blouses is the fitting bodice and coat sleeve, the drafting and

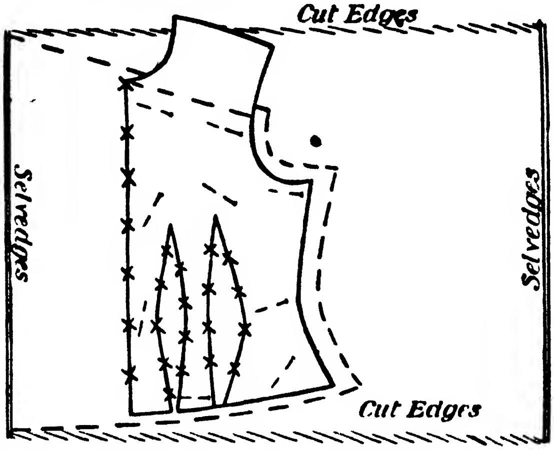
making of which have been fully described. This will, perhaps, explain why we have begun with the making of a bodice and not a blouse. We will now turn to the diagrams, first of all explaining that the portions NOT to be cut are marked —X—X. The turnings are indicated by a broken line — — —, and the outline of the pattern by a firm one.

In diagram 37 we have five blouses, as well as a back and yoke, cut on the cross, marked respectively *a*, *b*, *c*, *d*, *e*, *f*, and *g*, all of which can be evolved from the bodice pattern just described—or any other—as will be seen clearly in the following diagrams.

How to Cut the Blouse. We will now describe each of the blouses sketched, and begin with *a*, which is a perfectly plain one suited to morning wear. To show how to obtain it we must turn to diagram 38, where the method of cutting it from the bodice pattern is shown, using that, of course, of the size required. Place the front of this to the selvedge 1½ to 2 inches from these and pin carefully in place. Now arrange the back portions above this as shown, placing the centre part first, then the curved side-piece, and the under-arm piece next. Pin all these carefully in position, so that they will not slip, mark them, and cut round the outline thus made, as shown by the broken line. Remember to keep the waist lines even and allow good turnings at the fronts, shoulder, and under-arm seams. This will give one back and two fronts, the method of cutting the sleeve being described later on, whilst the collar is the pattern given in the drafting of the bodice. If the back be a trifle wide, it is quite easy to reduce the under-arm piece in width and add what has been thus taken off to the front part.

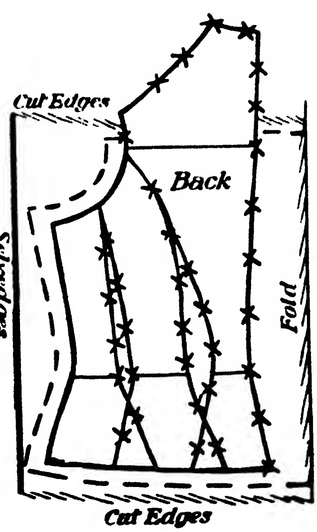
Blouse *b* is cut exactly the same as that we have already described, except that the material fronts—and back too, if preferred—are tucked *before* cutting out, the tucks being the deep ones stitched as described in PART I. (see TUCKING), but they can be arranged in any way desired, provided the tucking be done before cutting out, as already said. This method is more satisfactory than when the material is cut out first, when it is neither easy to keep the tucks regular nor the right way of the material.

An American Yoke. In the third of the group of blouses under consideration, marked *c*, we have one with what is known as the American yoke, this being cut all in one, and for which our bodice is still the basis. In this shape the fronts come on the cross, the back being cut selvedge-ways. The diagram shows how to obtain this, but it is well to remember that for this shape the pattern must fit perfectly at the shoulder, as no alteration is possible when it is once cut out.



40. FRONT OF AMERICAN BLOUSE

Place the back and front portions together as shown, the two shoulder lines meeting, and the centre back to the fold and of the depth required. Pin in place, draw a line across from neck to armhole, for the depth needed, and cut out as indicated by the broken line. The result will be a piece like that shown in the opened-out yoke. Two pieces of the same shape and size are required, as it must be double, like nearly all yokes for unlined shirt blouses [39].

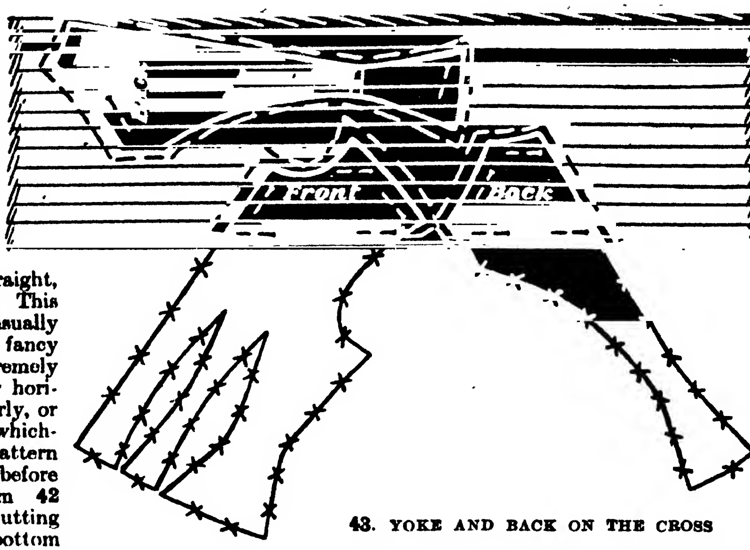


41. BACK OF AMERICAN BLOUSE

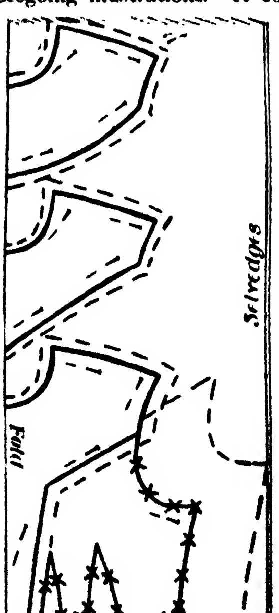
Having obtained the yoke, we must turn to the next diagram, for the method of cutting the blouse front [40]. In this the centre front is placed from 4 to 6 inches (depending on the thickness of the material and the size of the pattern) from the selvedges to allow for the front fulness. Measure the depth of yoke, and then draw a line slanting upwards across the material, as indicated by the broken line. Always allow a sufficiency of fulness in the front of a blouse, so that it shall set well and easily, as skimpiness not only makes it uncomfortable, but detracts in no small degree from the effect of an otherwise well-made blouse. For the back, place the various portions of the pattern as described and shown in diagram 41, allowing a little fulness at centre back, and for the depth of yoke.

We will now take *d* of our evolutions. Here

we have a yoke extending in a point to the waist in front, a style which enjoys much popularity at the moment, and makes up becomingly and smartly. It could be varied in several ways. For instance, the sides could be rounded off downwards, or made quite straight, as fancy may dictate. This style of yoke is usually expressed in lace or fancy material, but looks extremely well if tucked either horizontally, perpendicularly, or V-shaped fashion; but whichever be preferred, the pattern of the yoke is needed before tucking. In diagram 42 we see the method of cutting it out depicted, at the bottom of a trio of yokes. The outline is shown by a firm line, the turnings by a broken one, whilst the shape of the side-portions is further indicated by a broken line [42]. The back of the blouse is quite plain, and the method of cutting-out will be easily understood from the foregoing illustrations. It could, of course, be made in any other way preferred, whilst the fronts may be tucked instead of gathered, but in this case a little fulness should also be allowed, especially if the material happen to be of thin texture.



43. YOKE AND BACK ON THE CROSS



42. THREE DIFFERENT YOKES

Other Yokes. The fifth of the group of blouses (*e*) illustrates one with a rounded yoke, the method of cutting which is seen in the top one of the trio, the lower front portion being cut to fit this, as described for the last.

The centre one of the trio of yokes from which we have already obtained *c* and *e* depicts a pointed affair which may be preferred to the rounded one, in which case the bodice portion is cut similar to the front for the American yoke-blouse, except that the slope will be reversed, as the greater depth is required at the sides. The yoke of blouse *e* in the sketch is made of strips of lace united by faggotting, for which the pattern is needed.

The last sketches of the group in 37—those marked *f* and *g*—show an arrangement of stripes for yoke and back, as it may happen that a much better effect can be obtained by not having them quite straight. In the case of broad stripes, for instance, for a rather stout figure, the result would be more becoming and graceful were they arranged to come in a V at the back as shown. The method of cutting both yoke and back is indicated in the diagram. Be careful to get the stripes to meet in both cases, and if the fronts be cut to match, they should be arranged in the same way [43]. With respect to the yokes of *shirt* blouses, the back should always be cut selvedge-ways, as the strain and wear mostly falls on this portion.

NOTE. The amateur should first cut the pattern in paper to get the right shape, and to avoid wasting the material.

In the blouses sketched the ordinary high collar has been shown, but of late transparent, or unlined, ones have been the fashion. When this is the case, the neck must be neatened by a narrow binding before putting on the lace. To do this cut a strip of crossway material (if the edge be not shaped it will do on the straight) long enough to allow turnings at each end, and about 1 inch wide, or a trifle less. Put the edge of this to the neck-edge on the right side, run together, turn over to meet the other edges, being careful to neaten the ends, and sew the lace to this on the right side.

To be continued

THE STATE LADDER OF LEARNING,

AND HOW TO CLIMB IT

THIS is the age of efficiency. In the keen competition of individuals and of nations we cannot afford to waste either time or money, and least of all can we waste men without paying the penalty in the race of progress.

Wherever there is a brain of exceptional power or a character of unusual pertinacity, it is the duty of the State to seek out its possessor, and to set him on the ladder by which he may raise himself and his fellows. And while it is the duty of the State, at once to itself and to the individual, to offer to every promising boy the means by which he may fit himself to do a man's work in the world, it is no less the boy's duty to himself and to his country to avail himself of the means so placed at his disposal.

Recent legislation has shown that the State at least realises its responsibility, and what is now required is that every boy in the kingdom should recognise that if he has fair ability and the will to do a certain amount of hard work in his youth, no position in the land is closed to him.

Every county and county borough has its own "scheme," and discharges its educational functions in its own way, but the general features of all the schemes are very much alike, and may be shortly described.

The First Rung of the Ladder. The first rung of the ladder is formed by the minor, or junior scholarships given by the local education authority to children in the public elementary schools, and in many cases to the children of parents of small means, whether they attend a public elementary school or no.

These scholarships are usually awarded to children between the ages of 10 and 14, on the result of examination. The number given in different counties and districts varies considerably. In London there were last year 14,000 candidates for junior county scholarships out of about 80,000 elementary schoolchildren of eligible age—between 11 and 12 years—and 2,166 scholarships were awarded; so that about 2¾ per cent. of the children leaving the public elementary schools of London in a particular year became scholarship holders.

The minor scholarship given by the different education authorities carries with it not only free education at a grammar-school or similar institution, but also a small grant towards the maintenance of the child. In London free education is given between the ages of 11 or 12 and 16 or 17, in addition to which parents whose income is less than £160 a year receive a grant of £6 per annum during the first three years, and £15 per annum during the two remaining years, parents with larger incomes receiving a smaller grant. Provincial authorities are not, for the most part, so liberal in the matter of maintenance grants, but the proportion of scholarships given to the number of children in the schools is about the same. The provision in some counties is particularly good. In Essex about 4 per cent. of the elementary school-children obtain scholarships.

The education of a minor scholar qualifies him for many positions in business, or for Civil Service clerkships and similar posts; but for the more ambitious boy it is only a stepping-stone to higher things.

Prospects at the Age of Seventeen. In some districts a boy can hold a minor scholarship up to the age of 18 or 19 years, but in the great majority of cases emolument lapses when the scholar has attained the age of 16 to 17 years. There are then three courses open to him:

1. He may enter a trade or profession, and attend a course of commercial or technical instruction at an evening school. Small scholarships are offered in most counties to pay the cost of such a course, and are easily obtainable.

2. He may obtain a continuation or intermediate scholarship, and proceed to study for two, or in some cases three, years at a technical college, qualifying himself for the better positions in the engineering and other scientific trades; or

3. The same scholarship will enable him to continue his grammar-school course, or in many cases to enter a conveniently situated public school as a day-boy.

Intermediate scholarships vary greatly both in value and in the number given. One hundred such are awarded in London, and children who have not held minor scholarships are allowed to compete if their parents' income is less than £400 a year. With these additional competitors in the field, the result is that only one in 20 of the London minor scholars is able to secure an intermediate scholarship. These provide free education at any of the London secondary schools, including St. Paul's and Merchant Taylors', as well as a maintenance grant of £30 a year.

Scholarships in the Provinces. In the provinces a larger number of children in proportion to the population are able to secure the scholarships, but these are not so valuable as the London ones, and in many counties they are so small that it is not possible for a scholar to attend a good school without a certain amount of hardship. But it is worth while to undergo the hardship, not so much for the sake of the better teaching which may be provided at the more expensive school, but rather in order to be able to enter Oxford or Cambridge on the same footing as the public-school boys, of which class these universities are largely composed.

The writer remembers well one of his own schoolfellows—a boy who seemed to us all to be a little peculiar, and whom we consequently "ragged" to a certain extent, until someone discovered that the boy's father was a mechanic, who pinched himself to enable his son, with the aid of a county scholarship, to keep up appearances at school. Then the boys' attitude changed at once; all were friendly to him at school, and their homes were open to him in the

holidays. He has passed through the university now, and is doing good work in the world in a sphere very different from that which he would have filled without the ladder by which he arduously climbed.

We have seen that it is possible for any boy of average brains and application to secure, by means of a minor scholarship, a good education up to the age of 16. The competition for intermediate scholarships is more severe, particularly in London; but fortunately these are not the only scholarships available for boys of 14 to 17 years of age. Nearly all grammar-schools, many of the City companies, certain charities, and pious foundations offer scholarships tenable for the most part at particular schools. The City of London and some of the Northern counties are particularly rich in such foundations, and information as to those available in any district can usually be obtained from the local education authority.

Help from Local Authorities. The body now responsible for public education in every county borough is the Borough Council. All districts outside the boroughs are directly under the authority of the County Councils as far as education is concerned.

Scholarships are granted in every case by the responsible authority, and a boy living in a borough is not in general eligible for a county scholarship. The proper course for a would-be candidate for any public scholarship is to write to the Clerk of the Education Committee of the County or Borough Council, under whose jurisdiction his parents reside. The clerk is generally in a position to give information, not only as to the scholarships granted by the committee, but also as to all the others for which boys residing in the district are eligible.

By one means or another, then, the child of the mechanic or of the labourer can obtain an excellent education up to the age of 18 to 19. At that time he is confronted by a serious problem. For many of the higher walks of life a university degree is a valuable, if not a necessary qualification. Shall he seek it at one of the old universities of Oxford or Cambridge, or at one of the many new ones dotted about the country?

The University Problem. There can be no doubt which of these degrees is the more valuable to the possessor, and if by any means a boy can get to Oxford or Cambridge, he should go there. On the other hand, a course at one of the other universities is far cheaper, costing from £30 to £40 a year to a boy living in the town, to which must be added the cost of lodgings in the case of a boy coming from a distance. The lowest cost at which it is reasonably possible to pass through Oxford or Cambridge is £140 a year, unless all the social advantages of the institutions are to be neglected. At some colleges, indeed, the cost is even greater. A man can scarcely live at Trinity College, Cambridge, for example, on less than £160 a year. It is possible to cut down expenses by entering as a non-collegiate student, but this is to reject the many scholarships offered by the different colleges.

Individual Ability the Best Guide. The real guide of a boy's proper course after leaving school is his own ability. Most local education authorities offer one or more scholarships to boys of limited means, to help them through the university. In London about 50 scholarships of a maximum value of £90 per annum are given yearly; but these and the smaller scholarships given in the provinces are not sufficient to enable a boy to go to one of the old universities unless he can also win an open scholarship for himself. The competition for these, however, is more severe, as the son of a mechanic may have for his opponent the descendant of several generations of scholars.

Now, there can be no doubt that a boy of really marked ability should enter at one of the more famous colleges, where the competition is heaviest and the prizes greatest. If he is so fortunate as to secure also a leaving exhibition from school, he may leave the senior county scholarship to a boy who needs it more, and save money at the university at the same time. On the other hand, a boy of more modest attainments may do very well for himself at one of the less-known colleges, though at Balliol, Oxford, or Trinity, Cambridge, he could not hope to win any emolument.

A boy who cannot secure any of the scholarships offered at Oxford or Cambridge had better abandon the idea of a career at either of these universities; but no boy of ordinary intelligence need anticipate such failure if only he will put his back into his work at school.

There are numerous scholarships and charities available, particularly to London boys, for the purpose of providing a higher education. The most valuable of these are the four Whitworth engineering scholarships, worth £125 a year for three years, open only to practical engineers. Of all these particulars can be obtained from the Board of Education, South Kensington.

There are also 22 science scholarships given annually to graduates of any university in the British Isles or Colonies, by the Commissioners of the 1851 Exhibition. The award is made on the recommendation of the College, and holders pursue their studies on lines approved by the Commissioners.

The Rhodes Scholarships. The most valuable of all the open scholarships to Oxford are not open to English boys. These are the scholarships founded by the will of the late Cecil Rhodes, and are worth £300 a year for three years. Sixty of these scholarships are assigned to the British colonies—namely, 9 to Rhodesia, 15 to South Africa, 18 to Australia, 6 to Canada, and 3 each to New Zealand, Newfoundland, Jamaica, and the Bermudas. Two are also given to each State or territory of the United States of America. Appointments to one-third of these scholarships are made every year. Five scholarships of the value of £250 for three years are also allotted annually to German boys.

The Rhodes Scholarship scheme is administered by Dr. Parkin, C.M.G., of 40, Elvaston Place, London, S.W

How to Obtain Technical Education. It is not always advisable for a boy, even if he has the ability, to pursue a course of study on public school lines up to the age of 18 or 19. Many boys' ambition points to success in the profession of engineering, or in one of the technical branches of science, rather than to a university career. The most usual course for a technical student is to enter a day technical college at the age of 17, but the selection of the college is a rather serious matter.

There can be no doubt that the engineering training given at Cambridge University is the best all round engineering course obtainable in this country. An ideal training for an engineer would perhaps be a Cambridge course, followed by a year of special study in America or Germany, before entering the shops; but the son of parents of slender means will find it difficult to justify such a course of action to himself.

A very excellent training can be obtained by means of a two or three years' day course at one of the provincial university colleges or such of the technical institutes as provide for day students. The cost of the former course is generally about £30, the latter about £15, per annum.

The selection of a college depends on the neighbourhood and the branch of science which is to be studied. Each institution has its special features. Thus, the Armstrong College at Newcastle is unrivalled for coal-mining and marine engineering, the Battersea Polytechnic for the mechanics of motor-cars, and the Sheffield University College for the science of metallurgy.

It is impossible here to give a general criticism of all the technical institutes of Great Britain, but a certain amount of guidance will be found in the table appearing in a later issue, and it is generally possible to get information as to local institutions by application to the local authority.

Scotland's Educational Advantages. The ladder is a steep one everywhere, and requires arduous climbing, but perhaps a Scotch boy has more facilities for the ascent than a native of the sister kingdom.

In Scotland, as in England, education is free up to the age of 14, but in Scotland it is now possible, thanks to the munificence of Mr. Carnegie, for every necessitous Scotch student to get, at any one of the four universities, his fees paid and books supplied, on application to the trustees. Besides the Carnegie trust, there are bursaries given by the universities and other institutions on the result of examination.

The real crisis of a Scotch boy's career arrives at the age of 14. The years between 14 and 17 are not provided for by junior scholarships in the systematic way prevalent in England, though in the larger towns excellent higher-grade schools are provided. There are, however, numerous local and miscellaneous scholarships available, and it must be remembered that the cost both of education and of living is lower in Scotland than in England, and that the greater sparseness of population makes it possible for a boy to combine schoolwork with lucrative duties in a very effective way.

To a certain extent, this will have to be done also by the Englishman who wishes to make the best of his university career. The scholarships at the Oxford colleges are seldom worth more than £80 a year; while at Cambridge, at the smaller colleges, at least, £60 a year is above rather than below the average, and a boy of average ability will find it very difficult to make more than £150 a year all told—a sum which does not supply a great margin for vacation expenses. Fortunately, a university man can generally secure some light tutorial work in the vacation; and some men who have desired a greater change of occupation have tried haymaking and harvesting with considerable success.

Ireland's Needs. Education has not as yet been systematised to the same extent in Ireland as in Great Britain—partly perhaps because the State has found it possible to leave the whole matter to the intensity of religious party feeling. In any case, education other than elementary is furnished almost entirely by schools conducted by religious societies such as the Christian Brothers.

These societies also divide the task of elementary education with the voluntary schools, and they do, to a certain extent, take it upon themselves to pass boys up from the lower to the higher schools under their control, by which means a ladder is provided, though not so broad a one as in England or Scotland.

Scholarships are provided in Ireland by the National Government. They are divided into Junior, Intermediate and Senior. The number awarded in 1905 were:

	Boys	Girls	Value
Junior to 16	83	38	£10—£20
Intermediate to 17	40	15	£10—£30
Senior to 18	56	13	£30—£80

Compared with the scholarships awarded in England, and particularly in London, these are rather small and few, but it is satisfactory to note that quite a large number of poor boys have passed with credit through Trinity College, Dublin, and the Royal University of Ireland, while a large proportion of the Maynooth students are entirely without private means.

What School-Board Boys Have Done. One of the chief difficulties in the way of the poor boy who enters into competition with the children of richer parents is the difficulty of getting room and quiet to work at home. Indeed, the struggle to climb the ladder which the last few years have provided requires not only pluck and effort on the part of the climber himself, but a great deal of devotion and self-sacrifice on the part of his parents. Happily, all these qualities are to be found in thousands of British homes. Thousands of boys are climbing up the ladder of learning, and every year they touch a higher point. Two board-school boys have been Senior Wranglers, and this year, for the first time, a board-school boy was elected to a Fellowship of Trinity College, the most distinguished reward of merit that Cambridge University can offer.

WHAT EVOLUTION REALLY MEANS

Reproduction—continued. Why does Variation take place? Acquired and Inborn Differences. Traits of Individuals. True Meaning of Evolution

By DR. GERALD LEIGHTON

The Germ Cell. We now know that the process of reproduction, as studied in the species we have taken, is in the first instance a very simple process of simple division of a complete individual into two. In that case the individual may be regarded as the germ cell, and the germ cell as the individual; there is no *specialisation.* Next we see two whole individuals concerned in the reproductive process, each exchanging a portion of themselves, as in paramœcium, but at the same time having the power of dividing into two as well. Then comes a stage in which a multicelled animal, hydra, reproduces also in two distinct ways, but in a definite order and in response to considerations of environment, producing first asexual individuals asexually; these, however, as they grow developing special parts of themselves as reproductive organs, male and female in one individual. The reproductive power in this generation is a specialised function, not a general one, a distinct advance in complexity. Germ cells (*i.e.*, sperms and eggs) are produced, from the union of which sexually new individuals arise which repeat the twofold method of reproduction.

Physical Immortality. The later stage still is that of the higher animals, in which the method of reproduction is restricted to that of sexual germ cells alone, which are continuous from one generation to another, and are not produced from the body cells of the individual at all. Moreover, the sexes separate, one individual carrying only male germ cells, the other only female germ cells. In the single-celled amœba death is not a necessary part of its history; it divides into two and is physically immortal as long as amœbæ exist. The individual is immortal because it is a germ cell. In the higher animal, where the germ cell and the individual have become distinct, the germ cell alone has the power of continued life. The individual dies sooner or later, but before doing so hands on the germ-plasm within to form the next generation. As it was received, so it is handed on, affected more or less (a problem to be considered later) by its temporary sojourn in the body of an individual. It is this continuity of the germ-plasm which alone makes the phenomenon of heredity possible, and maintains the distinctive characters of a species almost unimpaired as far as the most prominent characters of that species are concerned. The gravest problem that man has to study is to what extent and in what manner is the germ-plasm within the individual affected by conditions of external surroundings, if at all.

We have now taken a general view of the process of reproduction in relation to the continuity of life. We have seen how it is that individuals can arise similar to those which preceded them, either by simple fission or one of the other more complicated reproductive processes. In other words, we have seen the origin of the likenesses in individuals of a species. It lies in the continuity of the germ-plasm.

Variation of Living Beings. But individuals, even of the same species, are not all identical in every respect, though all have something in common. The next matter, therefore, to which we must direct our attention is the question of variation in living beings. We are here on the threshold of the deepest of all biological problems. Why do the various members of a family differ from each other? Whence the variation? Of what advantage is it? What part does variation in offspring play in the great problem of evolution? These are the questions to which we must seek an answer, even if it be a very imperfect answer. They are the questions which have engaged the best thought of mankind for generations, and in the elucidation of which the greatest minds are still engaged. The reason is obvious. The future of man is wrapped up in the answer to them, just as his past is explained by their correct understanding.

The very first thing to do in studying such a problem as this is to define our terms. Unless we are perfectly clear about the meaning of the terms we use, it is quite hopeless to come to a definite idea on the whole subject. Half the disputes on problems of this sort arise from different writers or teachers using the same word in different senses. A certain number of technical terms are unavoidable in any science, indeed they are most useful, so long as their meaning is exactly understood. Some of these terms are explained in the glossary attached to this course, but there are others which cannot be dismissed in a word or two, and which we must now examine more closely. To these we must give particular attention in order to understand what follows. It is specially to be noted that these terms have a wider and more extended use in popular language and literature than they have in biological science.

Definition of Terms. First we may define a group of terms all of which have reference to the various traits or characteristics of animals or plants. These terms are the following: *Inborn, Innate, Germinal, Congenital, Acquired, Somatic, Variation, Spontaneous, Evolution.*

Theoretically, at least, all the traits or characters which any living organism possesses belong to one of two groups; they are either inborn or they are acquired, and it is of the first importance that we should be perfectly clear as to what constitutes an inborn and what an acquired

character. The fundamental distinction is one of origin. In order to decide whether any given character is to be referred to one or the other group we must answer the question—Whence does this character arise? "*Inborn traits or characters are those which take origin in the germ-plasm*, which arise because the germ-plasm is so constituted that it tends, under fit conditions of shelter and nutrition, to impel or cause the germ cell to proliferate into an individual having those characters. Thus a man's head is inborn. It arises because the germ-plasm in the fertilised ovum whence he sprang was so constituted that it impelled that germ cell to proliferate into an individual having a man's head."

Acquired Characters. "*Acquired characters*, on the other hand, do not take origin in the germ-plasm; *they are modifications of inborn characters* caused by the play of forces from the environment on those characters after (as a rule) they have developed from the germ cell. Thus a man's hand is inborn. But if it be modified by use, disuse, accident, or the play of other forces from the environment the *modification* is an acquired character. All the effects of exercise are acquirements—for example, the enlargement which exercise causes in muscles. The effects of lack of exercise are also acquirements—for example, the changes in a diseased lung or an injured arm. Every modification of the mind is also an acquirement—for example, everything stored within the memory. If a man be blinded by accident or disease, his blindness is acquired. But if he came into the world blind—if he be blind by 'nature'—his blindness is inborn. If a son be naturally smaller than his father, his inferiority of size is inborn; but if his growth be stunted by ill-health or lack of nourishment or exercise, his inferiority is acquired. Inborn characters take origin in the germ. They express the hereditary tendencies of the individual, and, with variations, those of the race. Acquired characters take origin (as a rule) in the cell-descendants of the germ cell. They express the modifications of the hereditary characters of the race which are caused *in the individual* by the play of forces from the environment." (Dr. Archdall Reid.)

The Traits of Individuals. If we review the whole of the traits of any given individual, it is quite easy, by means of the above definitions, to say that certain of these traits are inborn while others are as certainly acquired. Thus, a head with two eyes, a hand with five fingers, the possession of organs for seeing and hearing, and so forth, are all obviously inborn characters. They are common to the race, and to many animals besides man. They take their origin in the germ-plasm from which these animals are developed. But there are other traits which cannot be so easily referred to one or other of these categories. Here is an individual who is an extraordinary mathematician. Is his mathematical faculty inborn or acquired? It depends on its origin. Some individuals have the mathematical faculty inborn; they are "born mathematicians." Others become very proficient in mathematics only by great and prolonged effort of study, by long subjection to a mathematical environment. Their proficiency is obviously acquired entirely; it is an acquired character.

The Fundamental Distinction. When we come to consider the problem of heredity, we shall see that it makes all the difference in the world. Meantime it is to be noted that while certain individual traits are obviously inborn, there are others which may be either inborn or acquired. In the same way there are certain traits which are obviously acquired. Thus the thickening of the skin on a coachman's hand in certain positions is plainly due to the constant irritation of the pressure of the reins. It is an acquired modification. The hand and skin are inborn, the thickening from the environment is aquired. So the power of expressing our thoughts in language is acquired. No infant was ever born able to speak. The organs of speech are inborn in the human race as is the *power of acquisition* of speech, but not speech itself. Speech comes only from the individual being placed in an environment of speech—it has to be acquired by gradual practice.

The fundamental distinction, then, between individual traits is one of origin, and a clear apprehension of this simple fact will prevent us falling into many an error. We saw previously that the two kinds of cells possessed by the higher animals are the germ cells and the cells composing the organs and tissues of the body. The terms "inborn," "innate," "congenital," and "germinal," all refer to characters which take their origin in the germ cells, and are synonymous terms in biology. They should never be used in any other sense in biology, or endless confusion follows. Similarly, all the characters which take their origin from the cells of the body are termed "acquired," or "somatic" (pertaining to the body).

Abnormal Characters. But now comes a most important consideration. It is a commonplace of observation that every individual differs, however slightly, from his parents even in inborn characters. No two are exactly alike, however close the resemblance. That is to say, every individual exhibits some new inborn characters, in addition to any differences which may be afterwards acquired. He differs *congenitally*. It generally happens that these new inborn characters are more or less slight modifications or alterations of characters which existed before. The skin may be thicker or more hairy, the nose larger, the mouth smaller, the foot broader, the sight keener, the hearing duller, and so forth, all alterations in traits which existed in preceding generations. All these new characters which are inborn, innate, germinal, or congenital, whether the new trait be a very pronounced one or merely a slight difference in degree of some former trait—all these are termed technically *variations*. If the new character is something quite unlooked for, and not in keeping with the usual characters of the species, it is termed an *abnormality*. Thus the possession of six fingers on the hand instead of the normal five is an abnormality.

Variation and Evolution. Variation, then, may be said to be the appearance of new characters which take origin in the germ-plasm, with the result that no two individuals even of the same species are exactly alike. It is the existence of variation in animals and plants which lies at the root of the problems of evolution, for without variation there could be no evolution. The fundamental importance of variation was fully recognised by Darwin, and he was the first to collect any large mass of facts bearing upon the matter, these being published in his work, " Variation of Animals and Plants." Darwin early realised that without variation there could be no such thing as organic evolution—evolution of living creatures, that is—and insisted upon this in his " Origin of Species." But the student of the problem nowadays must recognise that most of Darwin's facts relate to animals and plants in the domesticated state and not growing wild, and it seems probable that he himself hardly realised the magnitude and universality of variation in natural conditions.

" As to the causes of variation, Darwin did not hazard many conjectures. To do so would have been premature, and from actual lack of knowledge almost impossible. For many years after the publication of Darwin's work, the additions to our knowledge of the subject of variation were exceedingly small. Scientists seemed to rest content with the material he had collected, and to theorise on this alone, rather than to test their theories by a search after fresh facts and data. Within the last decade, however, the importance of the scientific study of variation has begun to be more thoroughly recognised, and has resulted in its being attacked with considerable vigour from several entirely different points of view. Investigations from the mathematical side have shown that many of the apparently disconnected facts of variation can be expressed with ease and lucidity by exact mathematical expressions, and that much material which has hitherto been regarded as quite outside all law was in reality amenable to treatment, according to the well-known laws of chance. Again, investigations from the experimental side have suggested much concerning the causes of variations, both genetic and somatic. Still, again, a fresh burst of activity in the collection of data regarding the actual facts of variation, more especially in respect of organisms found in a state of nature, has shown us how much in this branch of the subject there remains for us yet to learn." (Vernon.)

Variation is Universal. It cannot be too strongly insisted upon that not only does every animal show some variation, but that it varies in respect of all its characters, of whatever kind these may be. The variation may be greater or it may be less, but it always exists to some extent. Moreover, variation in one direction may be, and often is, quite independent of variation in another. Because one person has a longer arm than another, it does not necessarily follow that his neck will also be longer. On an average this may be so. Indeed, there is doubtless some degree of correlation between most parts of the body.

So much by way of consideration of the meaning of " variation," a phenomenon which we recognise as inherent in living matter and as being of universal occurrence. It remains to add that while most variations, as we have said, are somewhat small differences in characters already seen, other variations are of much greater magnitude. They are sudden appearances which do not seem to be mere continuations of former characters. Such sudden and striking differences are termed discontinuous variations. As we shall see later, it is very probable that these discontinuous variations have been the means of the evolution of species at a much more rapid rate than was formerly supposed. Next we must turn our attention to the meaning of the term " Evolution," after which we shall be in a position to discuss the causes of variation and their bearing upon the problem of evolution.

The Misuse of "Evolution." At first sight it might be supposed that it is quite unnecessary to explain a word which is in such common use at the present day, but as a matter of fact hardly any term is so commonly misused. All sorts of people use it to mean all sorts of things, and for that reason we must here consider very carefully in what sense we ourselves use it. It is also necessary to point out some of the more popular misconceptions of the term. The word itself etymologically means an act of unfolding or unrolling. In the science of obiology the word came into use in the early part of the eighteenth century to signify the theory which asserted that all the parts and organs were pre-formed in the germ, and that these gradually unfolded themselves, so to speak ; in fact, it was thought that a sufficiently powerful microscope would enable the observer to see all the structures of the animal pre-formed in the egg. " We now know that the original theory of evolution or unfolding of pre-formed organs and tissues was nonsense." (Saleeby.)

" The word owes all its meaning and value to Herbert Spencer, who had begun by attempting to show that there is in nature a law of progress. [See his great essay, " Progress, its Law and Cause."] The title of another essay, now historic, ' The Development Hypothesis ' (1852), indicates the word then used to indicate the process which he later came to call organic evolution. It was in the year 1857 that, having found that the law of universal and ordered change is anethical, and is by no means necessarily synonymous with progress, Spencer introduced the word evolution to indicate that ' universal redistribution of matter and motion ' which his genius discerned even in the days when all astronomical authority opposed the nebular theory." (Saleeby.)

The word, then, has a much wider and more far-reaching significance than popular usage is apt to associate with it. It refers not merely to animals and plants, but to every element in the universe, whether living or non-living. Applied to living organisms, whether plant or animal, we must speak of " organic evolution," not merely of " evolution." The necessity for this precise and accurate use of the term is to be found in

the great advancement of thought upon the whole subject of the origin of the present condition of the universe. The organic evolution of plants and animals is only one phase of a universal principle "proceeding in earth and sea and furthest sky, before time was and when time shall cease to be—for time is merely a human symbol, and the whole of human history is but as a watch in the night, a scarce considered stride in the path of the Eternal." (Saleeby.)

A Fascinating Theory. Professor G. H. Darwin, son of the immortal champion of the theory of organic evolution, has in his recent address to the British Association laid stress on the fact of this wider evolution. He reminds us that "the fascinating idea that matter of all kinds had a common substratum was of remote antiquity. In the middle ages the alchemists, inspired by that idea, conceived the possibility of transforming the baser metals into gold. . . . The object of alchemy, as stated in modern language, was to break up or dissociate the atoms of one chemical element into its component parts, and afterwards to reunite them into atoms of gold. Natural selection might seem, at first sight, as remote as the Poles asunder from the ideas of the alchemist, yet dissociation and transmutation depended on the instability and regained stability of the atom, and the survival of the stable atom depended on the principle of natural selection. Until some ten years ago the essential diversity of the chemical elements was accepted by the chemist as an ultimate fact, and, indeed, the very name of atom, or that which could not be cut, was given to what was supposed to be the final indivisible portion of matter. The chemist thus proceeded in much the same way as the biologist, who, in discussing evolution, accepts the species as his working unit. Accordingly, until recently the chemist discussed working models of matter of atomic structure, and the vast edifice of modern chemistry had been built with atomic bricks.

"Within the last few years, however . . . electrical researches . . . had shown that the atom, previously supposed to be indivisible, really consisted of a large number of component parts . . . . They were surely justified in believing that they had the clue which the alchemists sought in vain. . . . If the elements were not eternal in the past, they must ask whether there was reason to believe that they would be eternal in the future. Although the conception of the decay of an element and its spontaneous transmutation into another element would have seemed absolutely repugnant to the chemist until recently, analogy with other moving systems seemed to suggest that the elements were not eternal."

Atoms not Eternal. "At any rate it was of interest to pursue to its end the history of the model atom which had proved so successful in imitating the properties of matter. The laws which governed electricity in motion indicated that such an atom must be radiating or losing energy, and therefore a time must come when it would run down, as a clock did. When this time came it would spontaneously transmute itself into an element which needed less energy than was required in the former state. Thomson conceived that an atom might be constructed after his model so that its decay should be very slow. It might, he thought, be made to run for a million years, but it would not be eternal. Such a conclusion was an absolute contradiction to all that was known of the elements until recently, for no symptoms of decay were perceived, and the elements existing in the solar system must already have lasted for millions of years. Nevertheless, there was good reason to believe that in radium, and in other elements possessing complex atoms, they did actually observe that break-up and spontaneous rearrangement which constituted a transmutation of elements. It was impossible to say as yet how science would solve this difficulty, but future discovery in this field must surely prove deeply interesting. It might well be that the train of thought he had sketched would ultimately profoundly affect the material side of human life, however remote it might seem now from our experiences of daily life." (Presidential Address to the British Association.)

A New Realm of Ideas. It is impossible to read the above extract from Professor Darwin's address without being struck with the immensity of the thought which the modern use of the term evolution suggests. It seems to lift us into a new realm of ideas altogether, to bring before us conceptions of the universe undreamed of even a few years ago—conceptions which, though doubtless they have floated vaguely through the scientific imaginations of physicists and biologists, now for the first time are seen to be gradually assuming a definite shape. We realise that evolution really means that all things, living and non-living, are on an ordered journey, a journey which is immensely greater than what we usually associate with the term progress, and a journey which by no means necessarily coincides with our limited conception of what progress is. We realise that there is an inorganic evolution as well as an organic, and that both are included in any accurate usage of the word by itself. Evolution is *adaptive change*, and every theory of evolution is an attempt to supply the human mind with a reasonable explanation of such changes as are observed.

Misconceptions of the Term. If we have carefully followed the above explanation, a very few words will suffice to dismiss the popular misconceptions of the word evolution. Nothing can better exemplify the popular abuse of the word than the common query, "Do you believe in evolution?" In most cases what is meant is, "Do you believe that man has descended from some sort of monkey?"

This is no exaggeration; every teacher of biology has had the question put to him in this sense. In the light of what we know to be the meaning of the word, the question is absurd upon the face of it. Evolution does not mean, and never did mean, that man is a modified chimpanzee. That may be a true belief, or it may not—it does not affect the point; but it is not the meaning of evolution.

To be continued

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BOOKKEEPING EXPLAINED & SIMPLIFIED

A Business Transaction Defined. Double Entry Explained. A Complete Transaction Recorded. Problems in Posting

By A. J. WINDUS

BOOKKEEPING is the art of recording in a methodical manner those transactions to which money values can be assigned. For instance, a certain banker gave his daughter upon her marriage a cheque for £10,000. Obviously, this is a transaction which falls within the scope of our definition, and as such we should expect to find it duly recorded in the banker's books of account. But the banker was also concerned in a far more important transaction. In the cathedral at the marriage service he gave away his daughter to the bridegroom. This transaction was one to which no money value could be attached, and consequently no written or printed account of it could be regarded as bookkeeping.

Definition of a Transaction. For present purposes, therefore, we shall limit the meaning of the word *transaction* by defining it as any act involving the transfer of money or money's worth. Here, again, we must distinguish between a transaction and a business transaction. The banker's gift of £10,000 was an illustration of the former; a sale of bricks to a builder would be an example of the latter. If we insert the words "for value" in our former definition we shall then have the true meaning of the term "business transaction"—namely, any act involving the transfer for value of money or money's worth. The measure of the selling value of an article is called the *price*, and in some form or other every business transaction is done for a price. Even professional men place their knowledge and skill at the service of clients in return for a price, which may be variously designated as *honorarium* by a barrister, *bill of costs* by a solicitor, *charges* by an accountant, *fees* by a doctor, *commission* by a stockbroker, and so on.

The next point to consider is that every transaction wears a twofold aspect to each of the persons engaged therein. Thus the brickmaker sold bricks on credit to the builder, and thereby (1) his stock of bricks was diminished, but (2) he became a creditor of the builder for the price of the bricks. On the other hand, (1) the builder received £100 worth of bricks, but (2) he became a debtor for their value to the brickmaker who supplied them.

Double Entry. Now, it is the proper function of bookkeeping to record transactions in such a way that their twofold or double effect is clearly seen. It is not enough for the brickmaker's ledger to show that the builder owes £100 for bricks delivered—that would be mere single-entry bookkeeping—it must also show that the stock of bricks has been diminished. This would appear from the Sales account, which would be credited with £100, the amount already debited or charged to the builder. For every debit there must be a corresponding credit.

Again, in the *builder's* books of account it is not enough for the ledger to show that the brickmaker is credited with £100—that, again, would be mere single-entry bookkeeping—it must also show that the builder received the bricks. This would appear from the Purchases account, which would stand debited with £100, the amount already credited to the brickmaker. For every credit there must be a corresponding debit.

Originally it was thought that the observance of this cardinal principle made it necessary to enter the separate amount of every transaction under two different headings in the ledger, and hence arose the term *double entry*.

Double Entry Abridged. But in the United Kingdom it has long been recognised that it makes no difference to the final result whether, for example, sales for £50 to A, £75 to B, and £100 to C—after being duly debited to the personal accounts of A, B, and C respectively—are credited one by one to the Sales account as £50, £75, £100, or are posted to that account in one total of £225. The saving in time and labour by the second method is considerable, and we cannot fail to notice that whereas the term "double entry" implies six postings to the ledger—twice three entries, as above—we accomplished our object by the second method with four only—three debits and one credit. As a matter of fact, the accounts in a set of books kept by double entry arrange themselves in the form of a mathematical equation. The debit of any particular account is not necessarily equivalent to the credit of the same account, but if we have done our work properly, if we have carefully followed out the rule that there must be no debit without its corresponding credit, then the following equation holds good:

Sum total of all debits = sum total of all credits.

We may demonstrate this by taking the foregoing example and slightly elaborating it. Assume that A and B settled their accounts in full on April 28th, 1905, and that C paid his account on April 8th, less 2½% discount. Suppose, moreover, that X, from whom A, B, and C bought their goods, contemplated going out of business, and that in executing the several orders received from A, B, and C in March, 1905, he had cleared out the remainder of his stock-in-trade at cost price. On the

1st April, 1905, the position was this: X had already disposed of his fixtures, fittings, and office furniture and the lease of his business premises, and had realised all the business debts owing to him—sometimes termed Book Debts—except those of A, B, and C. There was standing to his credit in the books of his bankers on April 1st the sum of £922 10s.—reduced later in the day by cheque £20 drawn for Petty Cash—but X owed £125 to D for money lent, and, as we have seen, A, B, and C together owed X £225. On the 29th April, just before the books of X were finally closed, the various ledger accounts appeared as under:

EXTRACT FROM THE BOOKS OF X.

Dr. CASH ACCOUNT. *Cr.*

Date		Cash received			Bank Lodgments			Date		Cheques drawn		
1905								1905				
April 1	To Balance ..				922	10	0	April 1	By Cheque for Petty Cash ..	20	0	0
8	,, C	97	10	0	97	10	0					
28	,, A	50	0	0								
	,, B	75	0	0	125	0	0					

Dr. A's ACCOUNT. *Cr.*

1905 Mch. 15	To Goods	50	0	0	1905 April 28	By Cash	50	0	0

Dr. B's ACCOUNT. *Cr.*

1905 Mch. 17	To Goods	75	0	0	1905 April 28	By Cash	75	0	0

Dr. C's ACCOUNT. *Cr.*

1905 Mch. 31	To Goods	100	0	0	1905 April 8	By Cash	97	10	0
						,, Discount	2	10	0

Dr. D's ACCOUNT. *Cr.*

					1905 Jan. 2	By Cash (loan)	125	0	0

Dr. STOCK-IN-TRADE. Cr.

		£	s.	d.			£	s.	d.
1905 Mch. 1	To Balance	225	0	0					

Dr. SALES ACCOUNT. Cr.

		£	s.	d.			£	s.	d.
					1905 Mch. 31	By Sundries	225	0	0

Dr. TRADE EXPENSES. Cr.

		£	s.	d.			£	s.	d.
1905 April 8	To C (discount)	2	10	0					
29	„ Sundries (petty cash) ..	20	0	0					

Dr. X'S CAPITAL ACCOUNT. Cr.

		£	s.	d.			£	s.	d.
					1905 Mch. 1	By Balance	1022	10	0

A Trial Balance. We may now construct a table of debits and credits, or, to use the technical language of Bookkeeping, we shall proceed to draw out a *Trial Balance.*

DEBITS.	£	s.	d.	CREDITS.	£	s.	d.
Cash	1145	0	0	Cash	20	0	0
A	50	0	0	A	50	0	0
B	75	0	0	B	75	0	0
C	100	0	0	C	100	0	0
D	—	—	—	D	125	0	0
Stock	225	0	0	Stock	—	—	—
Sales	—	—	—	Sales	225	0	0
Trade Expenses	22	10	0	Trade Expenses	—	—	—
X Capital	—	—	—	X Capital	1022	10	0
Total Debits .. £	1617	10	0	= Total Credits .. £	1617	10	0

Thus we find that, although the debits to a particular account are not always equivalent to the credits on the same account—D, for example, has a credit of £125, but no debit—yet the sum total of all the debits equals the sum total of all the credits. Indeed, to the reflecting mind, no other result is possible. Once let it be granted that the *posting*—or entry—of a debit to any account in the ledger pledges us to the entry of a credit for a like amount somewhere in the ledger, then, no matter how numerous the postings are, if we have done our work correctly, the sum total of all the debits will invariably equal the sum total of all the credits. Therefore, by double entry we are always in possession of a most valuable check upon the mathematical

accuracy of the books of account. Going a step farther, we agree that it is immaterial to the final result whether we post items one by one or in total, so long as we observe the rule that the whole is equal to the sum of its parts.

For instance, we notice in the Sales account a credit of £225, which corresponds to the separate debits of £50 to A, £75 to B, and £100 to C, so that we are as truly carrying out the fundamental law of double entry in this case as if we had posted three credits to Sales account of £50, £75, and £100 respectively, instead of a total credit of £225.

But a new question now confronts us. We are informed, for example, that C has taken a discount of $2\frac{1}{2}$% off the statement of account for £100 sent to him by X, leaving a balance of £97 10s., which C has remitted by cheque. We are asked to show how these transactions would appear in C's own ledger. We cannot do this, however, until we know whether to debit or credit X for the cheque remitted and for the discount deducted. At this point, therefore, it would be well for us to commit to memory the six secondary rules derived from the primary law of a debit for every credit and a credit for every debit.

Rules Relating to Debit and Credit. Of these six rules, three relate to debits and three to credits. Incidentally, it may be mentioned that the debit side of an account is always to the left and the credit side always to the right of a page or folio in the ledger.

Charge or Debit to the Accounts of	(*a*) Those persons who receive anything, the value of what they receive. (*b*) Those things which come in (as Cash, Goods, Office Furniture), the value thereof. (*c*) Losses, Expenses, and Allowances, items relating thereto.
Discharge or Credit the Accounts of	(*d*) Those persons who give anything, by the value of what they give. (*e*) Those things which go out (as Cash, Goods, Bills Payable), by the value thereof. (*f*) Profits, or sundry gains, by the items relating thereto.

Remember that three G's are credited:

1. Persons who *give.*
2. Things which *go out.*
3. Sundry *gains.*

We are now able to answer the question proposed above as to C. It was stated that he sent a cheque for £100, less $2\frac{1}{2}$% discount, or £97 10s. *net*, to X in full discharge of his indebtedness. Here are two transactions, or, rather, it is one transaction in two parts—first, the deduction of discount £2 10s.; second, the giving of a cheque for £97 10s. Take the second first. Cash goes out, therefore, by rule (*e*), cash is credited £97 10s.; and X receives cash, therefore, by rule (*a*), X is debited £97 10s.

Now for the other part of our transaction. X, by means of a printed notice on the statement of account sent to C—such as "subject to $2\frac{1}{2}$% cash discount if paid within ten days"—promises C that he will make him a present of sixpence in the pound if the whole amount of the debt is paid promptly. C avails himself of this offer, and thus makes a gain of £2 10s. By rule (*f*), some account representing profit must be credited by the amount of the item, and accordingly we post £2 10s. to credit of "Discounts Received" account. But if £2 10s is credited, a similar amount must be debited.

A Problem in Posting. It is a little puzzling at first to know where to post this debit, and the rules do not seem to throw much light on the matter. No doubt we shall speedily arrive at the conclusion that because X was a creditor for £100 for goods supplied, but has since received £97 10s. *in settlement*, there ought to be no balance at all on his account, and that by debiting £2 10s. thereto we should kill two birds with one stone, for we should get rid of an inconvenient debit, and in doing so close the account of X in C's ledger. In fact, this procedure would be perfectly correct, but it is important that we should be able to justify it by a reference to one or other of the six secondary rules above mentioned. These, when thoroughly understood, will give us every information required to enable us to record in proper debit and credit form all the multifarious transactions with which modern bookkeeping is concerned.

Let us, therefore, attack the problem from another direction.

X tells C that, on one condition, he will accept £97 10s. in settlement of the debt of £100. Why does he do this? Are we to assume that X is giving money away to C, whom perhaps he has never seen? Not at all! X is one of those men who believe that "business is business" and not a mere parlour game, and we may rest assured that he did not forgo any portion of his full "pound of flesh" or any fraction of the whole debt of £100 without receiving some advantage therefrom. What was the advantage? Surely it was the benefit derived from prompt payment.

On referring to C's account in the books of X, we find that the goods were sold on March 31st, and that C paid for them on April 8th, or less than ten days thereafter. If he had chosen to keep X waiting for his money for a month or two, paying the full amount of £100 at the end of that time, X could not have objected. But X remembers the proverb that "He gives twice who gives quickly," and it is well worth his while to offer C an inducement to pay before the actual due date. The reasons which influence business men to offer discounts and other concessions will be discussed more fully hereafter; but as to X, his impending retirement and intention to go abroad as soon as possible are sufficient grounds for his anxiety to collect with all speed the debts due to him.

To be continued

Continued from page 473

PRACTICAL GEOMETRY & OBJECT DRAWING

Plain and Diagonal Scales. Scale of Chords. Sector. Application of Scales. Triangles and Quadrilaterals. A Lesson on the Cone and Cylinder

By WILLIAM R. COPE

Scales. It is often necessary to make drawings larger or smaller than the objects represented. It would be very inconvenient to draw the plan of a building full size, as it would be too large for practical use; but if it were drawn smaller, with the same ratio in all its parts, it would enable anyone to tell the relative size or proportion of all parts. To obtain these proportions correctly a scale is used. Thus, if for every foot on the building we use one inch on the drawing, the latter would be $\frac{1}{12}$ the size of the building, or we say the scale of the drawing is one inch to the foot. The $\frac{1}{12}$ is called *the representative fraction*, because it indicates the ratio each line of the drawing bears to the object represented.

There are occasions when it is advisable to make the drawing larger than the object, such as the details of the small parts of a watch, clock, and small instruments.

The simplest form of a scale is one of equal parts, and is called a *plain scale*. All scales must be constructed with very great care, and drawn with a very sharp pencil or fine pen to ensure absolute accuracy. By studying a few examples the student will soon understand their construction and use.

Plain Scales. 104. To Draw a Scale of $\frac{3}{4}$ in. to 1 ft. to Measure 6 ft. and Show Feet and Inches. Draw two parallel lines about $\frac{1}{10}$ in. apart. Set off $\frac{3}{4}$ in. six times, then each of these parts represents 1 ft. Divide the first part into 12 equal divisions, each of which will represent 1 in. When figuring and naming the parts it is important that the *zero* should be placed as shown, so that dimensions may be taken off readily with the dividers. Thus, to take off 3 ft. 8 in., place one leg of the dividers on point 3 ft. and the other on 8 in. The distance between the legs represents 3 ft. 8 in. The representative fraction is obtained thus:

$$\frac{\frac{3}{4}\text{ in.}}{1\text{ ft.}} = \frac{\frac{3}{4}\text{ in.}}{12\text{ in.}} = \frac{3}{48} = \frac{1}{16}$$

105. To Construct a Scale of $1\frac{1}{2}$ in. to 1 yd. to Measure 3 yds. and Show Yards and Feet. Draw two parallel lines as before. Set off $1\frac{1}{2}$ in. three times, and divide the first part into three equal divisions, which represent feet. Representative fraction:

$$\frac{1\frac{1}{2}\text{ in.}}{1\text{ yd.}} = \frac{\frac{3}{2}\text{ in.}}{36\text{ in.}} = \frac{3}{72} = \frac{1}{24}$$

106. Draw a Scale of $2\frac{1}{4}$ in. to 1 mile to Show Miles and Furlongs, and to Measure 2 miles. Draw two lines as before. Set off $2\frac{1}{4}$ in. twice to represent miles, and divide the first part into eight equal divisions, which represent furlongs.

Diagonal Scales. These are used when the divisions become very minute. From 107 it will be seen that the construction is based upon the principle of similar triangles. Let the rectangle *ABCD* [107] be divided into four equal parts by parallels to *AB*, and the diagonal *BD* be drawn, then a number of similar triangles will be formed. Thus the triangles *CBD* and *JBF* are similar; therefore if *BJ* is half of *BC*, then *JF* is half of *CD*; in the same way *KE* is one-quarter of *CD*. As *CD* may be as small as we like, it can be easily realised how valuable this principle is. From a *plain* scale we obtain two dimensions, such as miles and furlongs, or yards and feet; but from a *diagonal* scale we may obtain three dimensions, such as yards, feet, and inches.

108. Draw a Diagonal Scale Showing Inches, Tenths, and Hundredths of an Inch, and to Measure 4 in. Draw a line and mark off on it four separate inches. Divide the first inch into 10 equal parts for tenths of an inch, then on a perpendicular erected at 10, set off 10 equal parts to any convenient unit, and through each draw parallels to the first line. Erect perpendiculars at 0, 1, 2 and 3; join 9 and *B* and through each division for tenths of an inch draw the other diagonal lines parallel to 9*B* as shown. The distance *CD* is $\frac{1}{100}$, *EF* is $\frac{5}{100}$ of an inch, and *GH* is $2\frac{27}{100}$ in. or 2·27 in.

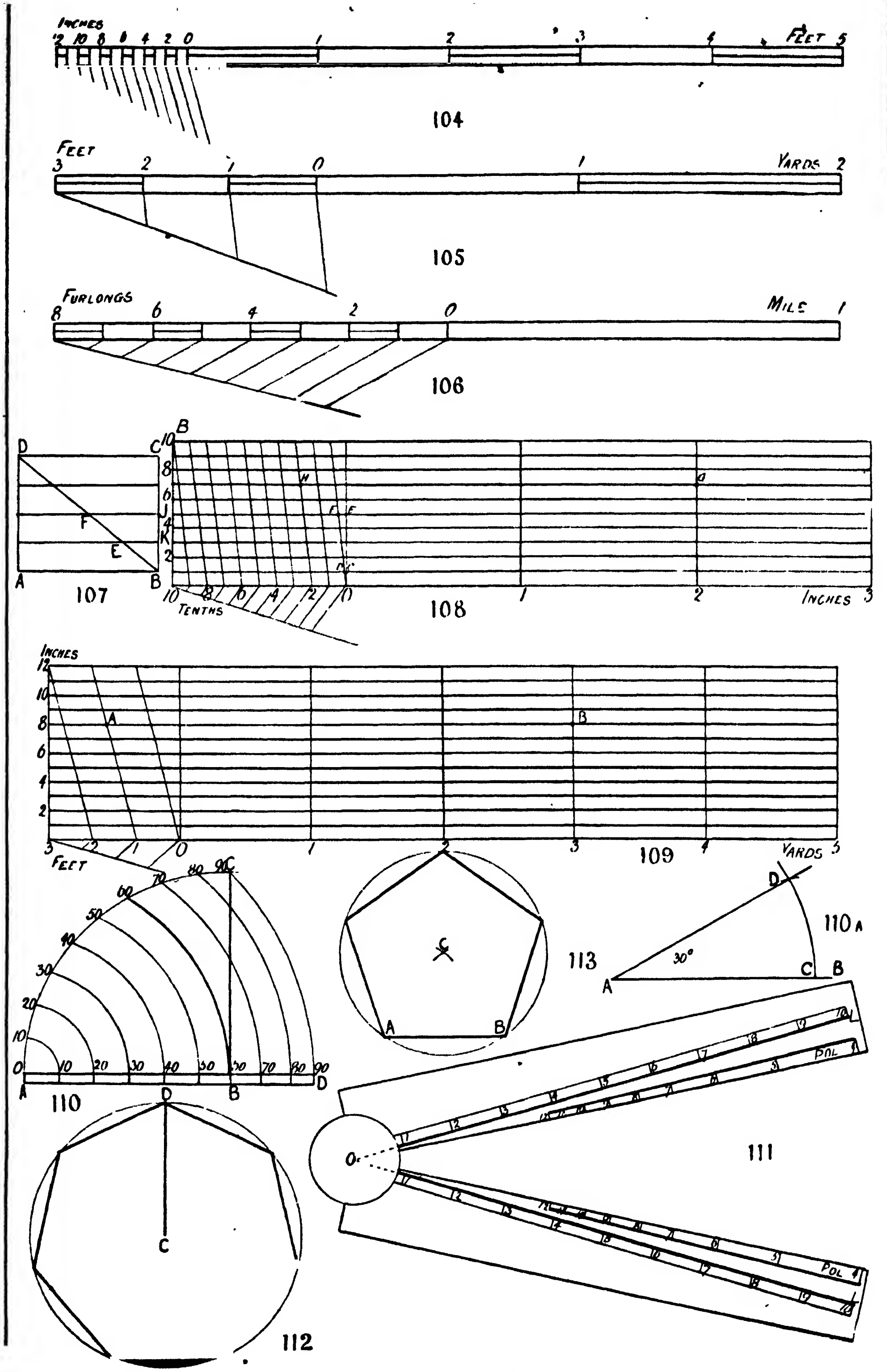
109. Draw a Scale of $\frac{1}{48}$ to Show Yards, Feet, and Inches, and to Measure 6 yds. This $\frac{1}{48}$ means $\frac{3}{4}$ in. to a yard, for $\frac{1}{48}$ of 1 yd.

$$= \frac{1}{48} \times \frac{36}{1}\text{ in.} = \frac{36}{48}\text{ in.} = \frac{3}{4}\text{ in.}$$

Draw a line, and mark on it $\frac{3}{4}$ in. six times, to represent yards. Divide the first division into three equal parts for feet. On a perpendicular erected at 3 feet set off 12 equal parts of any convenient unit, and through each part draw parallels as before. Erect perpendiculars at 0, 1, 2, 3, 4 and 5 yards. Join 2 ft. and 12 in., and draw other diagonals parallel to it. Figure and name divisions on scale as shown. *AB* represents 3 yd. 1 ft. 8 in.

Scale of Chords. This is used for measuring angles, and is marked on a ruler or protractor by the letters *CH* or *CHO*. The best way to know how to use this scale is to learn its construction.

110. Make a quadrant *ABC*. Divide the arc *AC* into nine equal parts of 10° each. The divisions 10, 20, 30, &c., on *AD* are found by taking *A* as centre with radius *A*10, *A*20, *A*30, etc., on arc *AC*, and marking them from *A* along *AD* as shown by concentric arcs. The distance from *A* to each division on *AD* is the chord of



PLAIN AND DIAGONAL SCALES. SCALE OF CHORDS. SECTOR

the angle containing that number of degrees. The divisions become smaller as they approach 90°. The distance 0 to 60 is *always* the radius of the arc to be used in making any angle.

Thus, to make an angle of 30°, draw any straight line *AB* as in **110A**. With either end, as *A*, as centre, and radius *A*60 in **110**, describe an arc *CD*. With *C* as centre and *A*30 in **110** as radius cut *CD* in *D*. Join *AD*, then *DAC* is an angle of 30°.

111. THE SECTOR. This instrument is formed of two flat legs hinged at *O*. Lines *OL* are drawn radiating from *O*, one on each leg, and are called *the line of lines*, by the use of which problems in proportion can be readily solved. There is also *the line of polygons* marked *POL*. Care must be taken to measure always from points on the lines (thick in illustration) drawn from the centre *O*. The following five problems show some of its uses.

TO BISECT A LINE. Open the sector until the transverse distance from, say, 8 to 8 on *OL* equals the given line. Then the distance from 4 to 4 is half the line.

TO DIVIDE A STRAIGHT LINE INTO FIVE EQUAL PARTS. Open the sector until the transverse distance from 5 to 5 on *OL* equals the straight line, then the distance from 1 to 1 will be $\frac{1}{5}$ of the given line.

FIND x IN THE PROPORTION $2 : x :: 5 : 2\frac{1}{4}$. With the dividers measure $2\frac{1}{4}$ in. Open the legs of the sector until the distance between 5 on *OL* of one leg and 5 on *OL* of the other is $2\frac{1}{4}$ in. Then the transverse distance between 2 and 2 on *OL* is the required distance x.

112. TO INSCRIBE A REGULAR HEPTAGON IN A CIRCLE. Open the sector until the distance from 6 to 6 on *POL* equals the radius *CD* of the circle. Then the transverse distance from 7 to 7 on *POL* is the side of the heptagon.

113. TO CONSTRUCT A REGULAR PENTAGON ON A GIVEN LINE *AB*. Open the sector until the transverse distance from 5 to 5 on *POL* equals *AB*. With *A* and *B* as centres, and the transverse distance from 6 to 6 as radius, make arcs intersecting at *C*. With centre *C* and same radius describe a circle. Set off *AB* round it.

Use of Scales. **114.** TO CONSTRUCT AN IRREGULAR POLYGON FROM A ROUGH DIAGRAM, THE DIMENSIONS ON A DIAGONAL *AE*, AND THE ORDINATES *bB*, *cC*, *dD*, etc., BEING GIVEN. *AE* = 9 ch., *Ah* = 1 ch. 30 l., *Ab* = 2 ch., *Ag* = 4 ch. 40 l., *Ac* = 6 ch. 30 l., *Af* = 6 ch. 80 l., *Ad* = 7 ch. 15 l. The ordinates *hH* = 2 ch. 60 l., *gG* = 1 ch. 25 l., *fF* = 2 ch. 20 l., *dD* = 1 ch. 60 l., *cC* = 1 ch. 10 l., and *bB* = 2 ch. 80 l. Scale, $\frac{1}{2}$ in. to 1 ch.

First construct the scale as shown. The diagonal scale is for obtaining measurements of 5, 10, or 15 l. Draw *AE*, 9 ch. long, according to scale, then set off *Ah*, *Ab*, *Ag*, &c., on it. At the points *h*, *b*, *g*, *c*, &c., erect the ordinates according to scale. Join *A*, *B*, *C*, *D*, *E*, *F*, *G* and *H*.

115. TO ENLARGE OR REDUCE A DRAWING BY A PROPORTIONAL SCALE. Say, to enlarge the given drawing of a gate, so that *AB* shall be $2\frac{1}{4}$ in. First construct the proportional scale by drawing the two lines *AB* and *Ab* at any angle with each other, making *AB* = *AB* and *Ab* = $2\frac{1}{4}$ in. Mark the several distances on small drawing on *AB*. Join *B* and *b*, and through *H*, *D*, *E*, *F*, *C* and *G* draw parallels to *Bb* as shown. Then the respective measurements along *Ab* are the required ones for the various parts for larger drawing.

116. TO ENLARGE A MAP. Make a proportional scale as before, and as shown in **116**. Set out the squares for the larger map according to enlarged scale, and then draw the map so that all parts come in corresponding positions in the larger squares to those of smaller squares.

Triangles. **117.** TO CONSTRUCT AN EQUILATERAL TRIANGLE ON A GIVEN STRAIGHT LINE *AB*. With centres *A* and *B* and *AB* as radius, describe arcs intersecting at *C*. Join *AC* and *BC*. Then *ABC* is the triangle required. (Euc. I.1.)

118. TO CONSTRUCT A TRIANGLE WITH SIDES 2.5 IN., 1.8 IN., AND 3 IN. First draw one side, say, *AB* = 3 in. as base; with *A* as centre and a radius of 2.5 in. describe an arc, and with *B* as centre and 1.8 in. as radius, describe another arc cutting the other in *C*. Join *AC* and *BC*, which complete the triangle required.

119. TO CONSTRUCT AN ISOSCELES TRIANGLE, THE BASE *AB* AND THE ALTITUDE *CD* BEING GIVEN. Bisect *AB* in *E* and at *E* erect a perpendicular, *EF*, equal to *CD*. Join *FA* and *FB*.

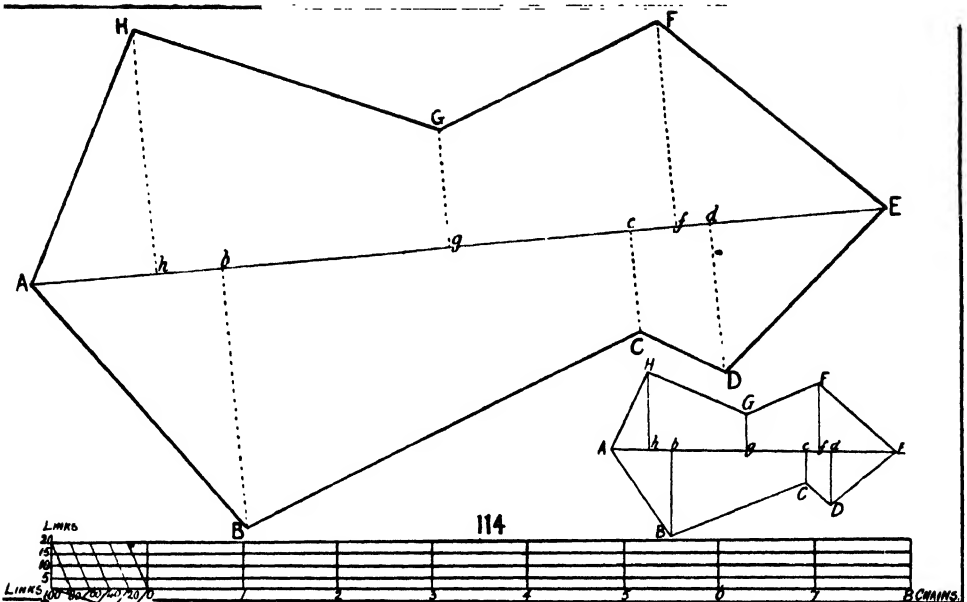
120. TO CONSTRUCT AN ISOSCELES TRIANGLE HAVING GIVEN THE VERTICAL ANGLE *CDE* AND THE BASE *AB*. With *D* as centre and any convenient radius cut off *DC* equal to *DE*. Join *CE*. At *A* and *B* make angles each equal to *ECD* or *CED*. Then *AFB* is the triangle required.

121. TO CONSTRUCT AN ISOSCELES TRIANGLE, THE VERTICAL ANGLE *C* AND THE ALTITUDE *AB* BEING GIVEN. Draw *DE* perpendicular to *AB*. Bisect the angle *C*. At *B* construct an angle. on each side of *AB* each equal to half the angle *C*. *DEB* is the required triangle.

122. TO CONSTRUCT A TRIANGLE, THE BASE *AB* AND THE RATIO 2 : 4 : 3 OF THE ANGLES BEING GIVEN. Produce *AB* any length. With *A* or *B* as centre, describe a semicircle and divide it into nine equal parts (2 + 4 + 3). Draw *AC* through 2. Join *A*4. Through *B* draw *BC* parallel to *A*4, meeting *AC* in *C*. *ABC* is the triangle required.

123. TO CONSTRUCT A RIGHT-ANGLED TRIANGLE THE BASE *GH* AND HYPOTENUSE *CD* BEING GIVEN. Take a line *AF* equal to *CD* as diameter, and bisect it in *E*. With *E* as centre, describe a semicircle *FBA*. With *A* as centre and *GH* as radius, cut the semicircle in *B*. Join *BF* and *AB*. *ABF* is the triangle required, with the right angle at *B*. (Euc. III. 31.)

124. TO CONSTRUCT A RIGHT-ANGLED TRIANGLE, THE HYPOTENUSE *AB* AND AN ACUTE ANGLE *C* BEING GIVEN. Bisect *AB* in *D*. With *D* as centre describe a semicircle on *AB*. At *A* construct an angle *BAE* equal to *C*. Join



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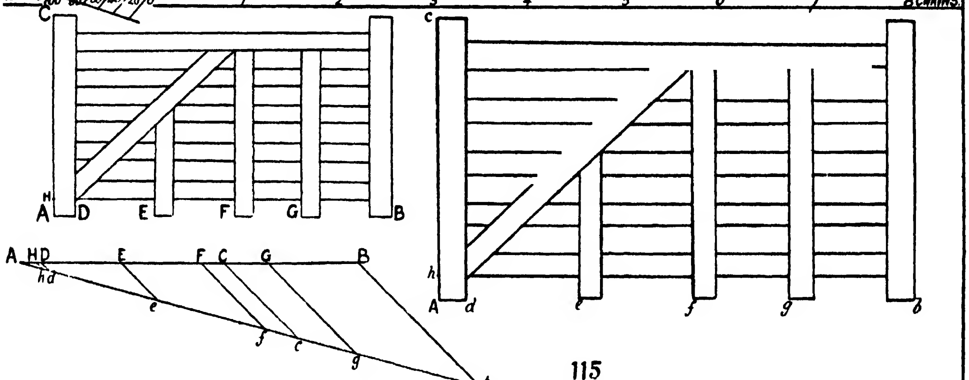

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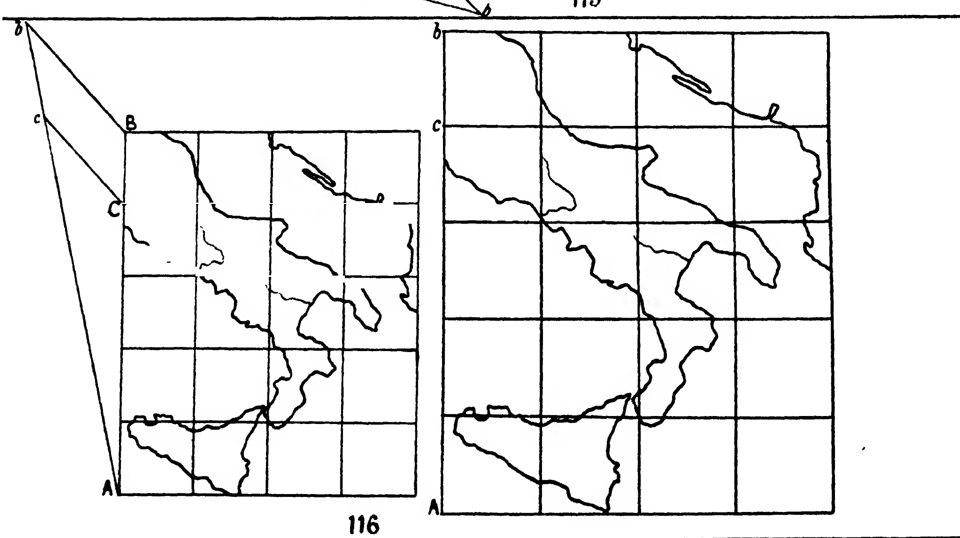


116

APPLICATION OF PLAIN AND PROPORTIONAL SCALES

BE. *ABE* is the triangle required. (Euc. III. 31.)

125. On a Given Base *AB*, to Construct a Triangle similar to a Given Triangle *CDE*. Make the angles at *A* and *B* respectively equal to those at *C* and *D*. Then *ABF* is the triangle required.

126. To Construct a Triangle, the Altitude *CD* and the Base Angles *A* and *B* being Given. Through *C* and *D* draw lines *EF* and *GH* perpendicular to *CD*. At *C* make the angle *ECG* equal to *A* and *FCH* equal to *B*. *CGH* is the triangle required.

127. To Construct a Triangle, the Base *AB* 1.75 in. Long, the Vertical Angle *C* 30°, and the Altitude 1.5 in. being Given. Bisect *AB* in *D*, and erect a perpendicular at *D*. At either end of *AB* make an angle of 60° (90°—angle *C*, 30°), intersecting the perpendicular at *E*. With centre *E* and adius *EA* draw the arc *ABFG*. Draw *FG* parallel to *AB* and 1.5 in. from it. Join *FA* and *FB*. *ABF* is the triangle required. The angle at the centre is always twice the angle at the circumference; thus, the angle *AEB* is twice the angle *AFB*. (Euc. II. 20.)

128. To Construct a Triangle whose Perimeter shall be equal to a Given Line *AB*, and the Sides in the Proportion 2 : 3 : 4. Divide *AB* in the proportion 2 : 3 : 4 as shown. With *D* and *C* as centres, and *DA* and *CB* as radii respectively, describe arcs intersecting at *E*. Join *DE* and *CE*. Then *EDC* is triangle required.

129. To Construct a Triangle, the Base *AB*, the Sum *CD* of the other Two Sides, and One of the Base Angles *E* being Given. A *B* make an angl *ABF* equal to *E*. Make *BF* equal to *CD*. Join *FA* and bisect it by the perpendicular *GH* cutting *FB* in *H*. *ABH* is the triangle required.

Quadrilaterals. **130.** To Construct a Square, the Side *AB* being Given. At *A* and *B* erect the perpendiculars *AD* and *BC* respectively, each equal to *AB*. Join *CD*.

131. To Construct a Square, the Diagonal *AB* being Given. Bisect *AB* by the perpendicular *CD*. With centre *E* and radius *EA*, describe a circle cutting *CD* in *C* and *D*. Draw *AD*, *DB*, *BC* and *CA*.

132. To Construct an Oblong or Rectangle, the Two Sides *AB* and *CD* being Given. At *A* and *B* erect the perpendiculars *AF* and *BE* respectively, each equal to *CD*. Join *EF*.

133. To Construct an Oblong, the Diagonal *AB* and One Side *CD* being Given. Bisect *AB* in *E*. With centre *E* and radius *EA* describe a circle. With centres *A* and *B* and radius *CD* cut the circle in *G* and *H* on opposite sides of *AB*. Join *AG*, *GB*, *BH*, and *HA*.

134. To Construct a Rhombus, the Side *AB* and One of the Angles *C* being Given. At *A* make an angle equal to *C*, and make *AE* equal to *AB*. With centres *B* and *E* and radius *AB* describe arcs intersecting at *D*. Join *BD* and *ED*.

135. To Construct a Rhombus, the Diagonal *AB* and One Side *CD* being Given. With centres *A* and *B* and radius *CD* describe arcs intersecting at *E* and *F*. Join *AE*, *EB*, *BF*, and *FA*.

136. To Construct a Rhomboid, the Two Sides *AB*, *CD*, and an Angle *E* being Given. Draw *FG* equal to *CD*. At *F* make an angle equal to *E*. Make *FJ* equal to *AB*. Through *J* draw *JH* parallel to *FG*, and through *G* draw *GH* parallel to *FJ*, cutting *JH* in *H*.

137. To Construct a Rhomboid, the Diagonal *EF* and the Two Sides *AB* and *CD* being Given. With centres *E* and *F* and radius *AB* describe arcs on opposite sides of *EF*. With the same centres and radius *CD*, describe arcs on opposite sides of *EF* intersecting the first arcs in *G* and *H* respectively. Join *EG*, *GF*, *FH*, and *HE*.

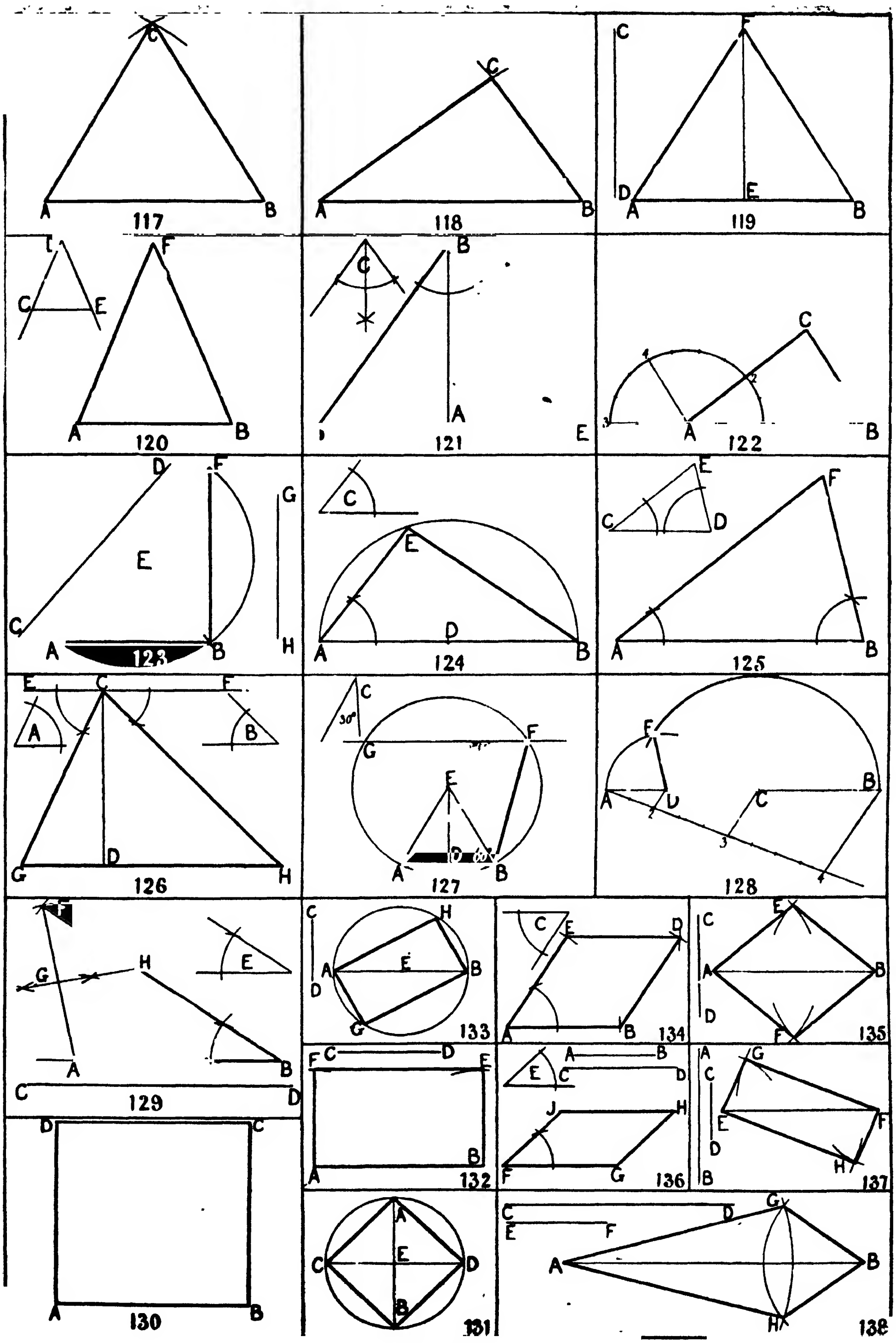
138. To Construct a Trapezium, the Diagonal *AB* and Two Pairs of Equal Sides *CF* ahd *EF* being Given. With centre *A* and radius *CD* describe an arc. With centre *B* and radius *EF* describe another arc intersecting the first in *G* and *H*. Join *AG*, *GB*, *BH*, and *HA*.

MODEL OR OBJECT DRAWING

In this part we shall explain how to draw conical and cylindrical-shaped objects. It is necessary that great attention should be given to the very important principles underlying the representation of the many thousands of such curved objects. More errors are made by beginners in drawing them than perhaps any other shapes.

The different appearances of a circle have already been explained [See **17**], so now let us take a simple one as our model. This object, like all others, may have an infinite number of apparent shapes, some of which are shown in **139–144**. To understand the fundamental principles of drawing such an object, let us imagine there is a line, called *the axis of the object*, passing through the middle of the cone from the apex to the centre of the base (*AB* in **139**), and another line, *CD*, called *the major axis of the ellipse*, along the surface of the base. It will be noticed that these two lines are at *right angles* to each other, and they *always* appear so, no matter in what position the cone may be placed. [See **139–144**.] From this we deduce the following very important rule: *The major axis of the ellipse always appears to be at right angles to the axis of the object.* This rule holds good, not only for the cone, but for the cylinder and all other similar shaped objects, such as tumblers, flower-pots, pails, jars, bottles, vases, barrels, etc. [See **145–160**.]

The Cone. It is sometimes difficult to see that this is so, but the student must endeavour to train his eye to see this fact by careful observation and comparison. It is as essential to remember it as carefully as the rule that receding parallel lines appear to converge. A great help at this stage would be to get a cone (or, if this be unavailable, a large funnel would do), place it in such positions as indicated in **139–144**, and endeavour to see that the rule holds good *always*.



TRIANGLES AND QUADRILATERALS

Fig. 139 is a view of the cone when standing upright with its base below the eye level, but 140 is the appearance when the base AB is level with the eye. Here, again, the outline alone does not represent the roundness of the cone, but if it were shaded, as was done in 30, it would appear round. Fig. 141 is a view of the cone lying down with its apex turned away from the spectator, while 142 is the apparent shape when the apex is towards him.

Fig. 143 shows the appearance when the cone is tilted with the edge of the base resting on a horizontal plane, and the apex raised and turned away from the observer. Notice how very much the length is foreshortened. Fig. 144 shows the cone lying down on a horizontal plane with its apex pointing directly towards the student. In 142 and 144, although the base is turned away from view, yet we see more than half the ellipse.

It is generally best to commence drawing the cone by sketching the straight lines CA, CB in 141 and 143, noting carefully the slant of each; then draw the axis CD of the object, which bisects the angle BCA, next determine the position of the point D, by observing what the apparent length of CD is, and afterwards draw through D the major axis EF of the ellipse *perpendicular* to CD, comparing its length with CD. Then obtain the apparent length of the minor axis GH, thus obtaining the four points F, H, E, G, through which the ellipse should be drawn. It must be noticed that CA, CB do not necessarily intersect the ends of the major axis at E and F, but they are *always tangents to the curve of the ellipse*.

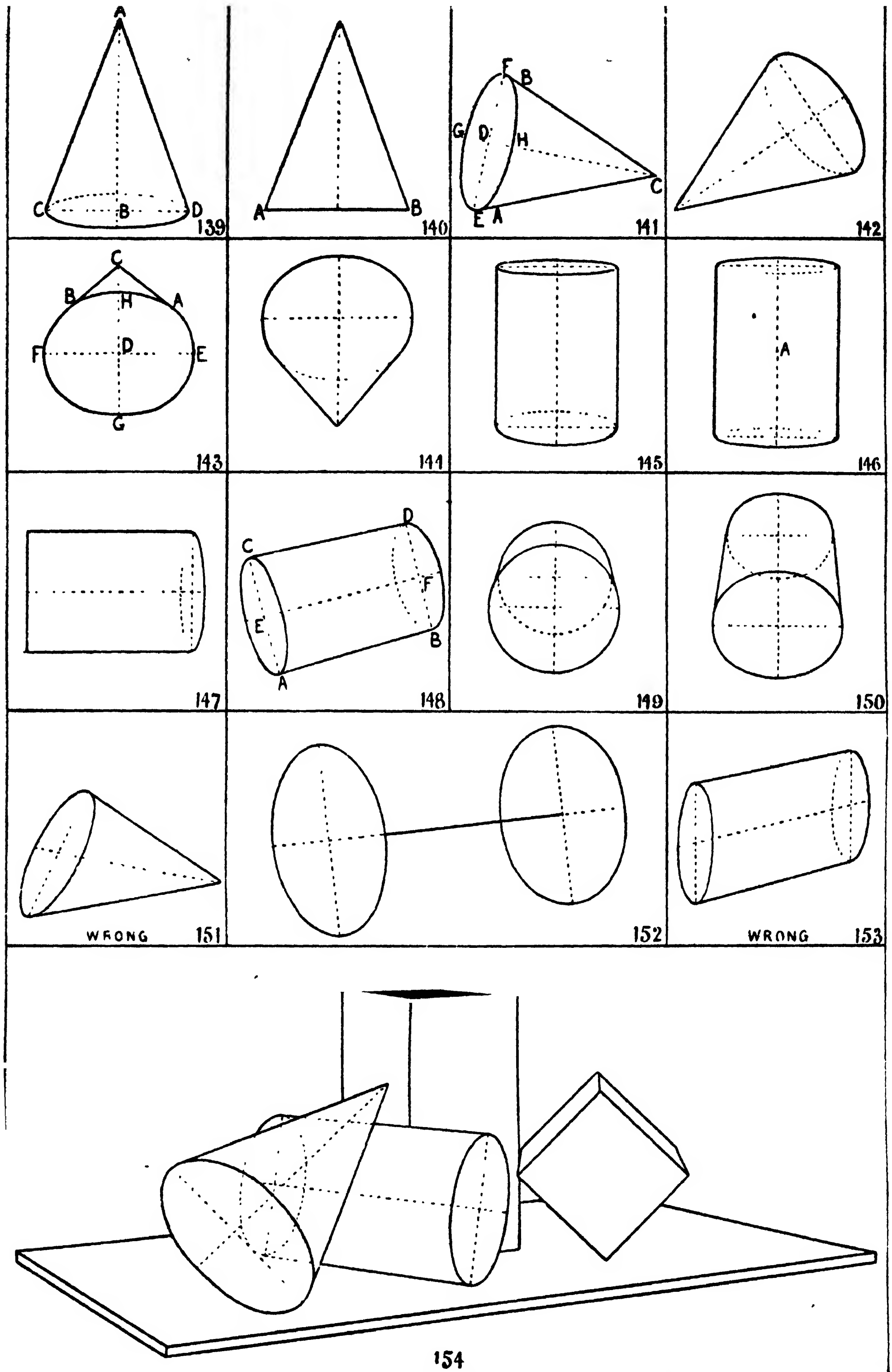
The Cylinder. After all this explanation concerning the cone, the drawing of the cylinder should not give a great deal of trouble. It will be seen in 145–150 that in every case the major axes of the ellipses are perpendicular to the axis of the object. But there is another very important observation to be made, and that is, the ellipses at each end are not exactly of the same shape. With an opaque object this difference is difficult to realise; but if the student makes a study of an object like that represented in 152 (which is constructed of two circular and equal pieces of stiff cardboard, with their centres joined by a piece of wood or stiff wire, so that the circles are kept rigidly parallel to each other, and perpendicular to the wood or wire), he will easily be convinced, by measuring with the eye and a pencil, that the further ellipse is *apparently rounder*, or more like a circle, than the nearer one is; the major axis of the further ellipse is a little shorter than that of the nearer one, while the minor axis of the further ellipse is (within certain limits) longer than that of the nearer one.

Commence to draw the cylinder by sketching the straight lines AB and CD [See 148], and before doing so, three facts must be observed: First, what slant AB and CD make with the surrounding objects; secondly, what distance apart they must be in order to obtain the correct relative thickness of the cylinder; and, thirdly, the right amount of convergence, since they recede. Next draw the axis EF, and afterwards proceed as with the cone, but bearing in mind the apparent different shapes of the ellipses. The straight lines which are part of the drawing of the cone or cylinder do not represent *edges*, but the boundary between the visible and the invisible portion of the curved surface of each object. This well illustrates how conventional *outline* drawing is.

Fig. 145 is the appearance of the cylinder in a vertical position below the eye level. Notice the different distances from front to back of the top and bottom ellipses. Fig. 146 shows the view when upright, but the eye directly opposite point A. Fig. 147 is the representation when the cylinder is lying on a horizontal plane, and the eye is directly opposite the left-hand edge. Fig. 148 gives the appearance when the object is lying in a horizontal plane but slanting away from the observer. Fig. 149 is an end view with the length very much foreshortened. Fig. 150, when resting on one edge, and the further end tilted up away from the student. In 151 is shown a very common error in drawing the cone when in the position shown in 141. It should be noticed that in 151 the major axis of the ellipse is not at right angles to the axis of the object, as it ought to be. Fig. 153 is an incorrect drawing of the cylinder, and shows two common mistakes, viz., the major axes of the ellipses are not perpendicular to the axis of the object, and the further ellipse is not wide enough. Fig. 153 ought to be drawn as in 148. In the wrong drawing [153] the major axes are vertical, and students may at first think that they ought to be so because the ends of the cylinder are really vertical planes; *but it does not follow that, because the ends are vertical, the apparent longest axis of the ellipse is vertical.* If the student will make searching observation of the object, he will see that the *apparent longest direction* of the ellipse is *slanting*, as shown in 148.

Useful Exercises. Good exercises at this stage would be to make studies of groups as shown in 154, and give most careful and searching observation to the proportion and perspective of the objects, in order to still further improve the power of *seeing correctly*. *Do not forget the spaces.*

To be continued



A LESSON IN DRAWING THE CONE AND CYLINDER

Group 15
HISTORY
4
Continued from page 421

EMPIRES OF THE EAST

History of Assyria—continued. Semiramis, Sardanapalus, and Nebuchadnezzar. Phœnicia and its Fleets. The Medes and Persians

By JUSTIN McCARTHY

A Famous Queen. One of the later Assyrian rulers was the consort of the famous Queen Semiramis, and Semiramis at his death became Sovereign of Assyria. To her was due the enlargement of Babylon, the construction of quays and great hanging gardens, and the protection of the city by a broad surrounding wall more than 40 miles in circuit. The last ruler of this Assyrian Empire was Sardanapalus, who has been made a frequent figure in the romance and poetry of many a modern nation down to the days of Lord Byron, whose famous tragedy is still sometimes presented on the English stage. He led, according to some traditional and possibly romantic accounts, a life at once effeminate and tyrannical, and provoked a rebellion among his Median subjects. The rebels at last conquered and imprisoned Sardanapalus in the capital. Sardanapalus refused to surrender, and rallying his remaining energies for one last and desperate resolve, he made elaborate preparations for a dramatic death. He had a funeral pyre prepared for him—the funeral pyre devoted in those days to receive the dead body of some great personage—and into its flames he flung himself alive, and there finished an inglorious career by a spectacular suicide.

Nearly two centuries after this event, some narratives tell us that another Assyrian king, who found himself unable to hold his throne against a coalition of the Babylonians and the Medes, sacrificed himself, after the example of Sardanapalus, on a funeral pyre, and the conquerors, becoming masters of Nineveh, destroyed the city altogether. Nineveh and all its monumental memorials were lost to the world for many centuries, and there was no actual certainty as to where its site had been. Even its ruins seemed to have passed away. Modern discovery, however, penetrating beneath the surface of the earth, found monuments, sculptures, and inscriptions enough to secure for the lost capital its place in the history of the world.

Modern Discoveries. Paul Emile Botta, a Frenchman by birth and bringing-up, the son of an Italian poet and historian, was endowed with a genius for archæological research and discovery. In 1843, within the memory of living men, he set himself to explore the site of Nineveh, and he discovered evidences enough beneath the earth, in monuments, figures, and inscriptions, to justify all that had been said about the arts, the civilisation, and the history of the long-lost city.

A little later Sir Austen Henry Layard made larger and more complete excavations through the region which had once known the great city, and there found the remains of four palaces. In one of these palaces, that supposed to have been erected by Sardanapalus, he discovered monuments adorned with bas-reliefs and cuneiform inscriptions, and some enormous images of human-headed and sometimes winged bulls and lions. He published " Nineveh and its Remains" in 1843, and " Monuments of Nineveh " in 1850. Botta sent his discoveries to the Louvre in Paris, and Layard sent his to the British Museum. Layard, who died in 1894, played an important part in English political life and in diplomacy, but his place in the world's history and the enduring celebrity of his name will be made for him by the triumphs he accomplished in helping, with such marvellous success, to restore the lost city of Nineveh to its secure place in human recollection. Other and more recent explorers have added, and we may be sure will still add, to his work; but we of these days may remember with complacency that the long-buried Nineveh was re-created by the genius, the energy, and the good fortune of men who belonged to our own time.

Nebuchadnezzar's Achievements. We must now return to the closing days of the Assyrian Empire. Babylon became the capital of Assyria after the destruction of Nineveh. Nebuchadnezzar recovered many of the lost provinces of Assyria, restored the ruined parts of Babylon, and restored also many of the temples throughout the whole land. Modern explorers have found many monuments which are themselves records of his successes, and records also of the destruction he inflicted on conquered enemies. He destroyed Jerusalem nearly 600 years before the Christian era, and he endowed Babylon with many magnificent trophies of his conquests and his captures.

But the great days of Assyria were coming to an end. The fame of the country and the conquering expeditions made by some of its kings had naturally begun to create powerful enemies outside its frontier lines and to tempt invasion. The Persian invaders under Cyrus, then king, besieged Babylon and captured it. Cyrus did not destroy the city he had taken, but made it his capital. The life and the exploits of Cyrus have been described by many Greek historians, but these histories are for the most part fanciful and even mythological relics of old-time hearsay supplemented by a good deal of guesswork, and have suffered much disparagement from the practical discoveries of modern days. It is certain that Cyrus became the most powerful of Asiatic sovereigns in his time, and that he adopted a policy, rare in those far-off days, and rare, indeed, in modern days, a policy of conciliation towards the differing religious faiths and practices of the races who had come under his rule.

The era of the Assyrian Empire thus came to an end. During her ages of independence Assyria made a deep mark on the history of Asia. Her system of government was somewhat advanced for an Asiatic despotism at that early stage of the world's progress. The sovereign of Assyria, like other Oriental sovereigns, was regarded as the absolute master over the lives and properties of all his subjects, but the king was not worshipped as a divinity, nor were there any castes in recognised existence—there was not even any system of sanctified or specially recognised classes among the subjects of the monarchy.

Many Gods. The religion of the Assyrians appears to have recognised the idea of one supreme divinity, Assur, but there were also many other divinities, including the nature triad, Anu, Bel, and Hea, and the celestial triad, Sin, Shamas, and Istar, and to these, too, worship was always offered. The sun-god was one of the highest of the deities, and to him high homage was paid and the adoration of the stars made a part of the national religion. There were also some minor divinities. The Assyrian priests were closely engaged in the study of astronomy, as it was known to their observation, and it is even said that the first regularly arranged and ordered system of astronomy and the measurement of time by the movement of the planets is due to their observation of the changes taking place in the position of the heavenly bodies. The Assyrians, or at least the less educated classes among them, had bird-gods and fish-gods and other divinities representing the various forces of nature. The inhabitants were very industrious, and were especially skilful in agriculture and commerce, in the making of carpets, textile fabrics, and ornaments of gold. We have already spoken of their remarkable skill in the sculptor's art, and the Greeks themselves derived some inspiration from Assyrian monuments and carved figures. Assyria may be described as one of the brightest constellations which our world could show in this dawn of its history.

Early Traders. The Phœnicians come next in the order of our narrative. Phœnicia was a country on the sea-coast of Selia in Western Asia, and its people were among the first, the most venturous, and the most successful navigators known to antiquity. As far back as twenty centuries before the Christian era the Phœnicians had been establishing colonies along the shores of the Mediterranean and in its islands. They are believed to have pushed their explorings even farther, and there is some substantial evidence to show that they visited Great Britain and Ireland. Among their principal cities were Sidon, Tyre, and Acre. The Phœnicians had, in the earliest days of which we can trace any evidence, been wanderers in search of a suitable settlement, and had established themselves in the region afterwards made famous by their name. The physical conditions of their settlement were in themselves an incitement and an assistance, for they had the sea in front of them and great mountain ranges behind them, in which mountain ranges were ancient forests offering ready material for the building of ships. The inhabited country thus became very prosperous, cities were founded and soon multiplied, and the populations greatly increased.

After a while the Phœnicians found it necessary to plant colonies elsewhere, partly to relieve the overcrowding of the home region, and partly with the object of spreading their commerce and adding to their revenues. They established themselves in the Ægean Islands long before the time of the Greeks, they sent their emigrants to establish commercial enterprises in Africa, Spain, Italy, and France, and at one time they had founded three cities in Sicily alone. Carthage, which played so important and powerful a part in history, was founded by Phœnician enterprise on the African coast.

The Wealth of Phœnicia. The Phœnicians compelled the Hebrews to yield to them two ports on the Red Sea, from which their fleets incessantly went forth on the quest for ivory and gold dust in the famous land of Ophir, spices in Arabia, pearls in the Persian Gulf, and all manner of valuable products in the Indian region. The Phœnician caravans went through Persia, Arabia, and Thibet, and brought back the silks of China, the furs of Tartary, and the jewels of India. The flourishing commerce of Phœnicia soon had the effect to be expected in those days, and in much later days, and it tempted the cupidity of invaders. The Pharaoh sovereigns were among the conquering invaders. Tyre was captured by many successive conquerors, and was reduced almost to absolute ruin by Alexander the Great.

Phœnicia had by this time lost her place among the ruling empires of the East, but she had the happy faculty of taking from her conquerors much that they had to give of art, industry, and science. Thus she obtained from Babylon a metric system, and got from Memphis the principle of alphabetical writing, which came to be adopted in one form or another by all the civilised peoples of the world. The story of the Phœnicians is in many of its characteristics a narrative of the earliest development of scientific education and of organised commerce. The Phœnician religion appears, like that of many other nations, to have begun as monotheism and to have degenerated into polytheism. Some of the best known names of their deities are Baal, Astoreth, Rimmon, and Molech. The Phœnicians were very religious, and carried their faith with them everywhere.

Medes and Persians. The Medes and Persians played a very important part in early history. They belonged to the race known as Aryan, and were made up of fair-skinned tribes which had found a settlement in the region of the Indus, and of the Iranians, who made their home in Media and in Persia. The separation of this race into two divisions is generally believed to have been caused by a difference as to religious belief. Both alike regarded Zoroaster as their great legislator, whose teachings are enshrined in the Avesta, the Persian sacred book.

Lofty Teachings. The principle of those teachings appears to have been considerably in advance of that of other polytheistic creeds. The central idea was that of a strife continually going on between the spirit of good and the spirit of evil. The spirit of good typifies the highest principle of life, and has for its emblem the sun, which was regarded as the type of all light and all progress towards happiness ; while the spirit of evil represented the whole combined forces which tend to the moral and physical degradation of man.

These two rival spirits had around each of them a vast and even infinite number of spiritual followers, a complete hierarchy, each struggling unceasingly to make its chief the ruling power over all. The divinities of good were believed to labour incessantly to teach man how to make his life all light, virtue, and progress towards happiness here and hereafter, while the evil spirits were occupying themselves in endeavouring to thwart man's progress towards good and to bring upon the earth all manner of demoralising influences and even all manner of destructive animal creatures. But this creed always accepted as an immutable end the ultimate triumph of good over evil, and it even went so far as to make it the consecrated belief that in the end the deity, who typified the spirit which the modern world regards as that of the Supreme Creator, was not only to conquer but even to pardon the enemies who had so long set themselves against his divine will. The goodness of the Creator was declared to be eternal as to time and limitless in its application, and even those worst of beings who incessantly and deliberately endeavoured to defeat his benign purposes were after a time to be called to redemption and enabled to enjoy the pure delights of heaven, and all the misled wicked ones of earth whom the influence of the demons had corrupted were also to attain redemption.

Zoroastrianism. The Persian heaven was a very exalted creation of mortal thought and feeling at such an early stage of the world's growth, and the Eastern races in general have not developed a higher ideal down to the present day. Zoroaster may be regarded as the founder of this reformed Persian faith which succeeded the creed adopted up to his time. The name of Zoroaster is but an ancient Greek modification of its Persian form, which has long since dropped out of European use. There is but little definitely known as to the period when he lived and taught, but it would appear that it cannot be assigned to any date later than 800 years B.C., and that it may even have belonged to a considerably earlier time. The teachings of Zoroaster insisted on faith as necessary to salvation, but also demanded good works. These teachings did not glorify or even recommend mere asceticism where the asceticism had no purpose for the general good of humanity, but taught that man's earthly career was in itself a sacred thing, and that work with a high purpose might be made as holy as prayer. Every religious service required prayers and an offering, and the prayer often was a confession of sin and a plea for mercy.

The exalted character and the pure form of worship which belonged to this people did not prevent their rulers and them from causing many troubles and disturbances in those parts of the world which were accessible for invasion and conquest, and we shall have to refer many times in the course of this history to some of the calamities which Persian sovereigns brought on the lands which they were eager to subjugate.

The Medes. We only begin to have anything like an authentic account of the Medes from the records and monuments of the seventh century before the Christian era. The Medes were an Aryan people, and followers of the faith of Zoroaster. Somewhere about that period Arbaces governed Media as an Assyrian province. Although a representative of the Assyrian king, he was led to revolt against Sardanapalus, and his rebellion proved unexpectedly successful. The Medes were now free from foreign rule, but their first enjoyment of freedom displayed itself for a considerable time in something like anarchy.

The right man appears to have come at the right time. This man was Dejoces, who obtained great influence over the people, and reigned for more than half a century, during which his people had a period of absolute peace and of growing prosperity. This era of peace did not last long. The son and successor of the Median sovereign made war against the Persians, and was himself killed by a king of Nineveh. The son of the slain sovereign sought to take vengeance by attacking the city of Nineveh, and the city was rescued only by an invasion of the Scythian race. The Scythians were at that time a barbaric people, and for more than half a century they made themselves known throughout Western Asia by their invasions and rapine.

The Banquet of Death. The story is told that the Median sovereign Cyaxares disposed of the Scythian chiefs by inviting them to a great banquet, during which the chief of the foreign guests were put to death and their followers expelled. That same Median sovereign afterwards captured Nineveh and reduced to subjection a large extent of Asia Minor. Lord Byron, in one of his Hebrew Melodies, has vividly commemorated the destructive powers of the Medes and Persians. The poet describes to us a great festival held at the court of Belshazzar, and tells how, at the high moment of the feast, the fingers of a hand were seen to write some letters on the wall. The King insisted on the meaning of the written words being revealed to him, but the wisest of his advisers were unable to decipher the inscription. One interpreter, however, presented himself—Daniel the Prophet. He was able to read the lines and expound their meaning, and they predicted the ruin and the death of the monarch. The closing lines of the poem foretell the fate and the ruin of Belshazzar, and predict his immediate death.

The Medes may be said to pass out of history when their separate dominion passed away, and they became absorbed into the domain of Persia.

To be continued

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THE WARFARE OF PLANT LIFE

The Struggle for Existence. How Plants Compete for Food and Light. Parasites. Plants that Feed upon Insects

By Professor J. R. AINSWORTH DAVIS

Naked-seeded Plants. We shall have occasion to mention some of these plants (*Gymnosperms*) in various connections; a few general remarks about them here will, therefore, be appropriate. As already mentioned, the ovules are not enclosed in an ovary, so that the pollen grains fall directly upon them, and there is no need for long pollen-tubes, as in pod-plants (*Angiosperms*), where the pollen grains fall upon a stigma.

The groups of Gymnosperms are three in number: (1) Switch-plants, etc. (*Gnetaceæ*); (2) Cone-bearers (*Coniferæ*): and (3) Cycads (*Cycadaceæ*).

Switch-plant Family (*Gnetaceæ*). The switch-plants (*Ephedra*), together with two other genera, make up a small family of somewhat peculiar forms, limited to the hotter parts of the globe. They present an approach to the pod-plants in the fact that their small flowers possess a perianth, and in this respect are more specialised than those of other gymnosperms.

Cone-bearers (*Coniferæ*). The great majority of gymnosperms belong here, familiar examples being monkey-puzzle (*Araucaria*), pine-trees (*Pinus*), firs (*Abies* and *Picea*), cedar (*Cedrus*), larch (*Larix*), cypress (*Cupressus*), juniper (*Juniperus*), yew (*Taxus*), and others. Many are forest-trees of considerable or great size, and in some parts of the world may cover large areas, as, *e.g.*, in the cooler parts of the Northern hemisphere. Among them are the gigantic Wellingtonia (*Sequoia gigantea*) and redwood (*S. sempervirens*) of North America. The former may attain a height of over 460 feet, exceeding every other known tree in this respect, though a species of eucalyptus is a good second (over 422 feet). The circumference of a Wellingtonia trunk may be as much as 112 feet, but this is exceeded by several other forms, sweet chestnut heading the list with 204 feet.

The resinous timber of various cone-bearers, the "soft woods" of forestry, is of immense economic importance.

Most members of the group are evergreen, with tough, leathery leaves, which, as a general rule, are either needle-shaped or resemble scales. The simple flowers are of two kinds, male and female, which in nearly all cases are in the form of cones, and possess no perianth [66].

Cycads. These are a small group (*Cycadaceæ*) of comparatively lowly forms, which in past geological times were very numerous and widely distributed, but have since been supplanted by higher types. They are limited to the hotter parts of the globe, especially Central America and Australia. A cycad is not unlike a palm in appearance, but usually with a much shorter trunk [67]. There are male and female cones, as in the last group.

THE STRUGGLE FOR EXISTENCE

We now come to the most fascinating part of botany, which deals with the relation between form and structure on the one hand, and the mode of life on the other. The constant struggle for existence which has taken place for countless ages, has led to the evolution of innumerable devices for the maintenance of the life of the individual and the perpetuation of the species.

Competition for Food and Light. We have already seen that food is largely taken up by roots from the soil, but, as the supply is limited, a plant is obliged to struggle vigorously to obtain its due share, and failure spells death. *Shallow-rooted* forms do their best to extract nutriment from the surface layers, and we may convince ourselves of the keenness of the competition in these layers by examining the under-side of a piece of turf, when we shall find innumerable pale rootlets tangled together in inextricable confusion. By sowing an assortment of grass seeds in a prepared patch of ground, we shall ultimately find that certain forms soon get the better of others, very largely owing to the possession of more numerous and more vigorous roots.

Deep-rooted plants mainly rely upon the water with dissolved salts to be found at some distance from the surface. The roots of many desert and shore plants are obliged to penetrate for an astonishing depth before they get what they require. In sand-sedge (*Carex arenaria*) and sea-holly (*Eryngium*), for example, a vertical length of some 48 ft. may be attained; while in some of the plants which live in the African deserts the roots may be twenty times as long as the parts above ground.

Fungi which Help Roots. The roots of most forest-trees and some other plants are invested in a close sheath of delicate threads (*mycorhiza*), which belong to the group (fungi) in which toadstools and moulds are included. These threads are closely connected with the roots, and may penetrate more or less into them [68]. We have here what is probably a mutual benefit association between tree and fungus. At any rate, the latter provides the former with some of the nitrogen-containing food which it requires, though it is doubtful how far a return is made for this.

A much clearer case of mutual benefit is afforded by leguminous plants, such as peas, beans, and the like. If the roots of one of these

are examined, a number of little swellings, or nodules, will be found here and there [69], which contain a large number of minute fungi, probably to be regarded as bacteria. These are provided with a sheltered home, and no doubt absorb some of their food from the root in which they live, but not to an injurious extent, though th nodules in which they live are the result of abnormal growth set up as a result of the irritation caused by their presence.

How a Plant Enriches the Soil. The benefit conferred by these microscopic plants on their large associates is very considerable. As we have already seen, nitrogen is an absolutely essential element in plant-food, and this, in the uncombined gaseous form, constitutes the greater part of the air, including, of course, that which is present in the soil. A green plant, however, is incapable of using this free nitrogen as food, for which purpose it must be combined with other elements to form *nitrates*. But the microscopic fungi in the nodules are able to cause the free nitrogen of the air in the soil to enter into combination, so as to form these very nitrates which are of such importance for the life of the leguminous plant.

Hence we see the desirability of including clover, or some other leguminous form, in a rotation of crops, for the arrangement described renders it unnecessary to apply expensive manures for the sake of the nitrogen they contain. Not only does such a plant cater for itself in this matter—or rather, is catered for by its fungus friend—but it actually leaves the soil enriched with nitrates for the benefit of the succeeding crop.

Competition Between Leaves. As leaves absorb from air the carbon dioxide which constitutes an essential part of plant-food, it is clear that the competition above ground for this must be as keen as the competition below ground for food of other kind. But here the matter is complicated by the fact that the leaves build up the simple nutriment of the plant into complex organic substances, and this can only be done by aid of the characteristic green colouring matter *chlorophyll*, which can only work in the light. Hence leaves have to compete for light as well as food.

Many plants adopt the bold policy of growing vertically upwards in the search for food and light. This is naturally carried to an extreme in forms which live for a number of years—*i.e.*, perennials. As we have seen, certain trees attain an enormous height, and in those which are either Dicotyledons or Gymnosperms the trunk thickens by annual additions of wood to the exterior, thus providing support to the increasing mass of foliage, while, at the same time, the root-system is correspondingly enlarged. The age attained by some of these trees is prodigious, a few of the best authenticated cases being as follows: cypress and yew, 3,000 years; sweet chestnut, oak, and cedar of Lebanon, 2,000; spruce, 1,200; lime, 1,000.

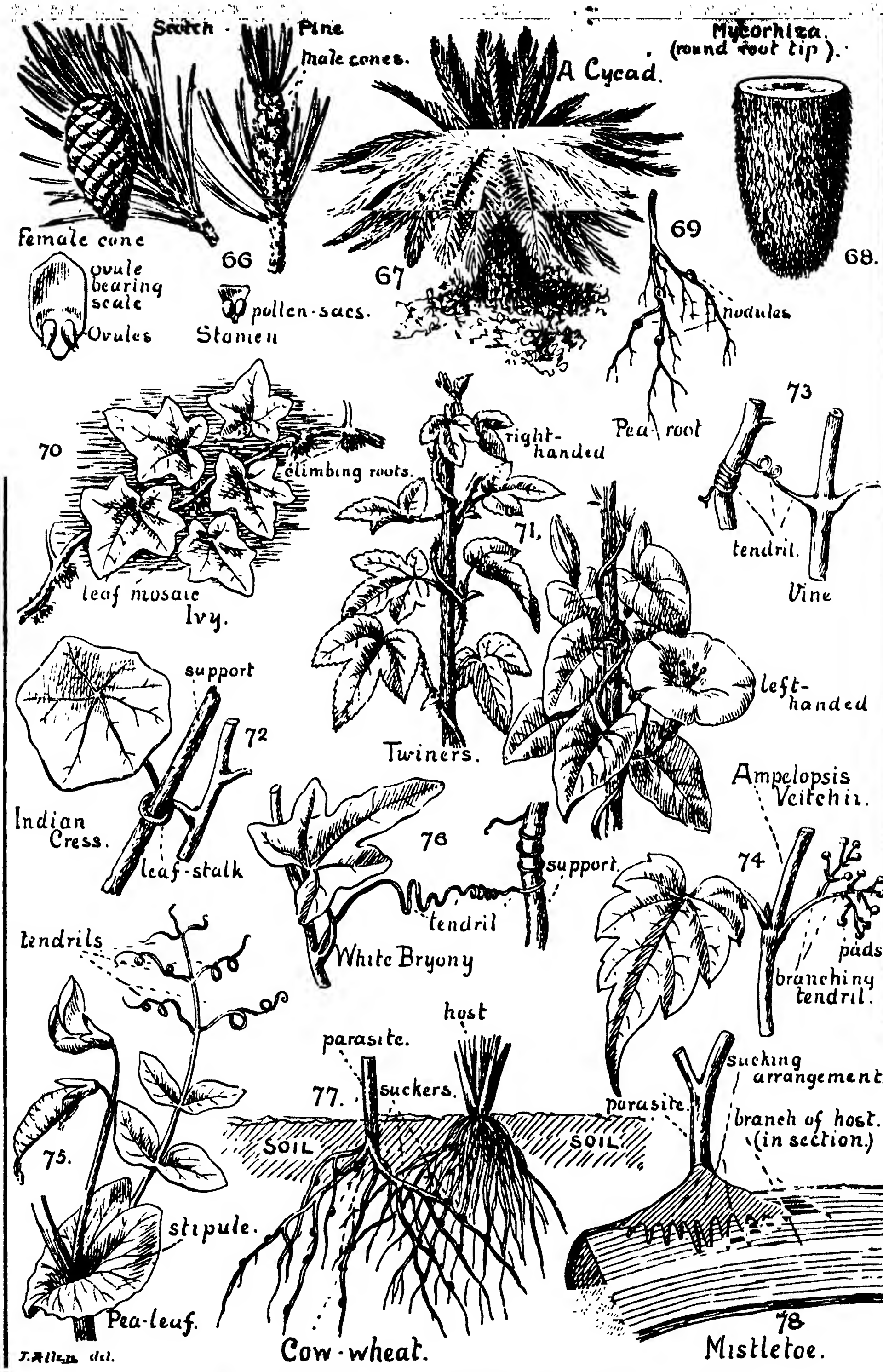
When trees are associated together into forests, their branches and foliage form a huge screen, by which light is more or less excluded from the ground beneath. In the case of pines, firs, and other evergreen forms, the obscurity thus brought about is permanent, and plants which require much light are unable to grow in the soil so overshadowed. Toadstools and other fungi, however, which are independent of light, flourish in woods and forests. Where the associated trees are *deciduous*—*i.e.*, shed their leaves in autumn—it naturally enough follows that the ground is sufficiently illuminated in spring to enable the growth of herbs which require plenty of light. And at this time of the year we shall find a number of plants carpeting such a "hard-wood" forest, and hastening to unfold their leaves and flowers before they are plunged into gloom by the growth of a dense green canopy above them. Conspicuous among such herbs are wild hyacinth, or English bluebell (*Scilla*), snowdrop (*Galanthus*), wood sorrel (*Oxalis*), and wood anemone. At the edge of such a wood, or in its open glades, herbs and shrubs are naturally more abundant.

Climbing Plants. By adopting a climbing habit, many plants are able to secure their due share of light without having to waste their substance in the manufacture of a strong vertical stem. A number of forms, without actually climbing, secure the display of their leaves by trailing or sprawling along the ground, as may be seen in periwinkle (*Vinca*). From this we pass to cases where the stem is studded with hooks, which render climbing possible, as in blackberry or bramble (*Rubus fruticosus*), that scrambles over hedges. An example on a large scale is afforded by the climbing palms, which stretch from tree to tree—holding on by their spiny leaves—and may attain the length of 650 feet.

The *root-climbers*, such as ivy (*Hedera helix*), adopt another method of ascent, for they hold on to tree-trunks, walls, or other objects by means of tufted roots which grow out from the nodes of the stem [70].

Another interesting method of struggling up to obtain light is afforded by the *twiners*, in which the stem winds itself round and round some support. This may be effected either in a right-handed or left-handed way, where the tip of the plant moves round in the direction of the hands of a clock or the contrary respectively [71]. To the former belong honeysuckle (*Lonicera*) and hop (*Humulus lupulus*); to the latter, bindweed (*Convolvulus*) and scarlet-runner (*Phaseolus multiflorus*). Indian cress (*Tropæolum*), clematis, and some other forms ascend by means of their leaf-stalks, which twist themselves round any firm objects of suitable shape [72].

Methods of Tendrils. All are familiar with the slender climbing organs known as *tendrils*, which are extremely sensitive to contact, and move about until they touch some stem around which they can firmly twine themselves. These peculiar structures may be specialised branches, as in the vine (*Vitis*) [73] and Virginia creeper (*Ampelopsis*). In most cases a tendril holds on to a cylindrical



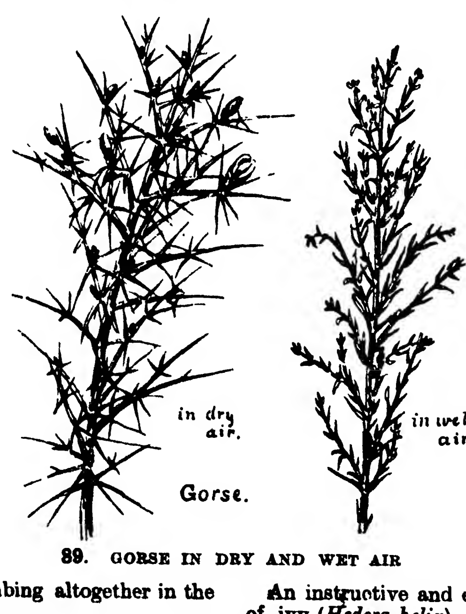
EXAMPLES OF NAKED-SEEDED, CLIMBING AND PARASITIC PLANTS

support, but in one kind of Virginia creeper (*A. Veitchii*) there is an arrangement by which even smooth walls can be climbed, for the tips of the tendril-branches swell into sticky pads, which adhere firmly to brick or stone [74]. The garden pea (*Pisum*) and many of its relatives have converted some of the leaflets of their compound leaves into tendrils [75]. In the white bryony (*Bryonia dioica*), our only native representative of the cucumber order, there are simple tendrils, which, after twisting round a support, coil into a tight spiral about the middle of their length [76]. This not only pulls the bryony firmly against the hedge up which it is climbing, but every spiral acts as a spring, which yields to the wind, preventing the plant from being forcibly torn from its anchorage.

Many tropical orchids and certain other forms are to be found growing on trees far from the ground, using these merely as a support, and not preying upon their sap. Such plants are *epiphytes*. Their roots, which are necessarily in the air, are of peculiar structure, absorbing moisture from the humid atmosphere of the forest in which they live.

88. LADY'S MANTLE

Parasites. A number of the higher plants have, more or less, given up the struggle for obtaining food in a legitimate fashion, and have adopted the parasitic habit, developing suckers, by which they extract food from other forms which are getting an honest living. A number of such forms are to be found in forests, where they attach themselves to the roots of various "hosts," as organisms are called, which must perforce give up some of their juices to unscrupulous associates. The phenomenon is by no means limited to forests, but may be seen here and there wherever vegetation is dense and rank, and where the device of parasitism has saved certain plants from succumbing altogether in the struggle for existence.



89. GORSE IN DRY AND WET AIR

Half Parasites. Some members of the foxglove order (*Scrophulariaceæ*) are green in colour, and partly get their food in a legitimate, partly in a parasitic, fashion. Such half parasites are eyebright (*Euphrasia*), louse-wort (*Pedicularis*), and cow-wheat (*Melampyrum*). Upon their roots are little swollen suckers, which fix themselves to the roots of their neighbours [77]. The mistletoe (*Viscum album*) fixes itself to the branch of a tree [78].

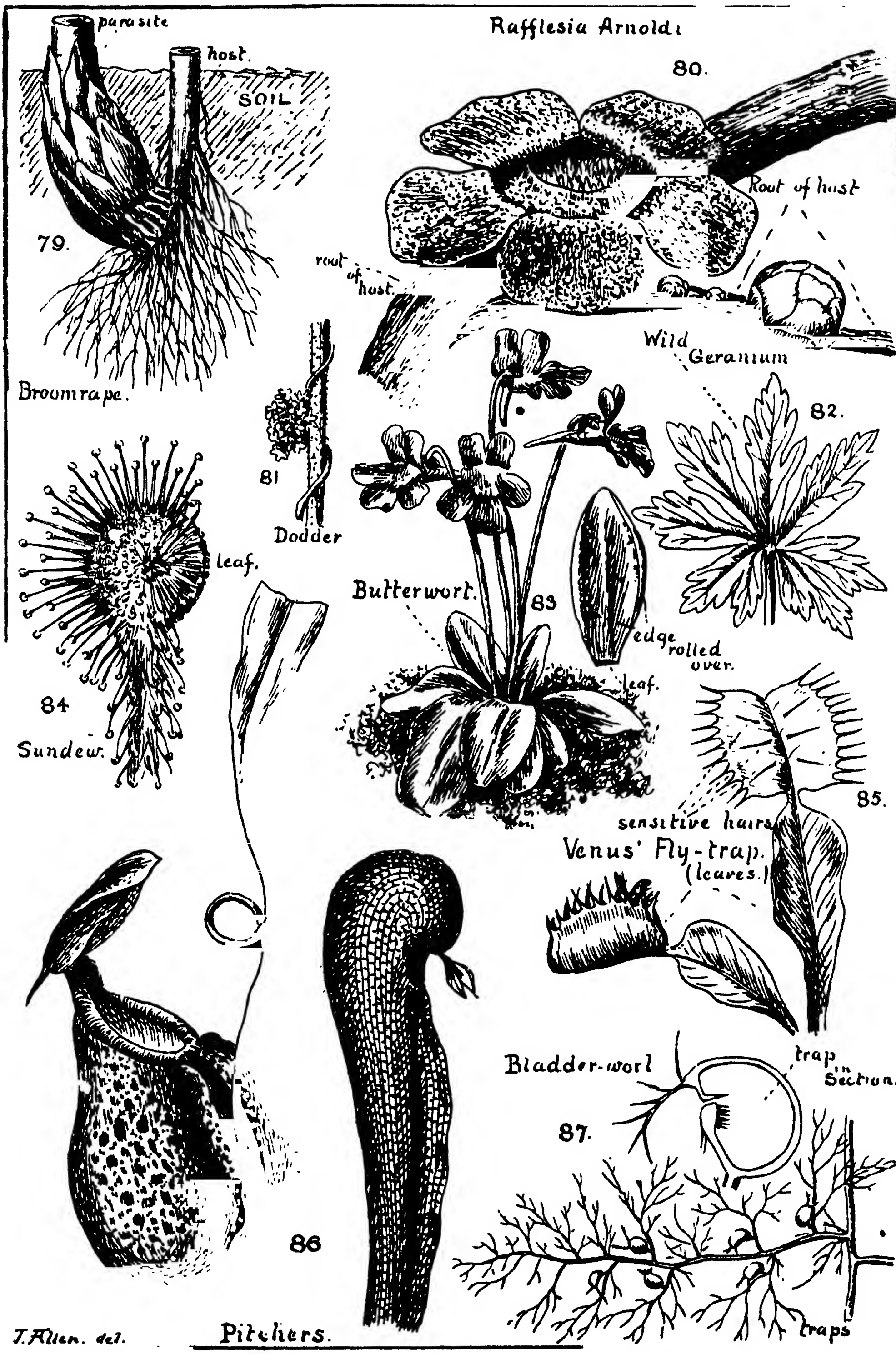
Full Parasites. Not distantly related to the plants last mentioned are the brownish broom-rapes (*Orobanche*), which have given up the green colouring matter for which they have no need, and of which different species attack the roots of broom and other shrubby leguminous forms, ivy, hemp, milfoil, scabious, etc. [79].

The members of one small order of parasites (*Rafflesiaceæ*) are found in the tropical forests of both old and new worlds, and some of them are remarkable for the enormous size of their blossoms. The most extraordinary species in this respect (*Rafflesia Arnoldi*) is native to Sumatra, where it grows upon the roots of wild vines, and bears gigantic flowers over a yard in diameter, the largest known [80]. They smell like putrid meat, and attract carrion-flies.

Another very notable parasite is dodder (*Cuscuta*), a degenerate member of the bindweed order (*Convolvulaceæ*), which twines round the stems of its victims and extracts their sap by means of sucker-like organs [81]. Hemp, clover, and flax are among the cultivated plants attacked.

Leaf Mosaics. We have seen that the shape of leaves and the method of their arrangement have reference to the utilisation of light. In a climate like our own, where sunlight is not too abundant, the necessity for making the most of it has caused the evolution of a great variety of *leaf mosaics*, in which a number of adjacent leaves or parts of leaves fit together to make up an almost continuous sheet of green, without blank spaces, and suggesting the relation of parts in a piece of mosaic work. The leaf rosettes of daisy, dandelion, etc., and the foliage of many trees furnish excellent examples.

An instructive and easily studied case is that of ivy (*Hedera helix*). When this plant applies itself closely to the ground, a tree trunk, or a wall, its leaves are illuminated from one side only, and each of them is provided with five sharp lobes, which fit neatly into the corresponding indentations of their neighbours [70]. But in such a place as the top of a wall we shall find shoots growing straight up into the air, and



EXAMPLES OF PARASITIC CARNIVOROUS PLANTS

receiving light from all directions. Under such circumstances the leaves are of a continuous egg-shaped outline, retaining only the angle at the tip.

The blades of many leaves are deeply divided, sometimes in a very complicated fashion, and in a "compound" leaf there is a splitting into a number of distinct leaflets. Such an arrangement is often found in plants which are crowded together—*e.g.*, in a hedgerow, and it is clearly of advantage in enabling a plant to take advantage of narrow spaces through which light penetrates. A good example is the common herb Robert, or wild geranium (*Geranium Robertianum*) [82]. Such a division, however, may have come about as an adaptation to conditions of other kind. Sometimes, for instance, it may be explained as an arrangement for preventing wind from tearing the delicate tissues of the leaf.

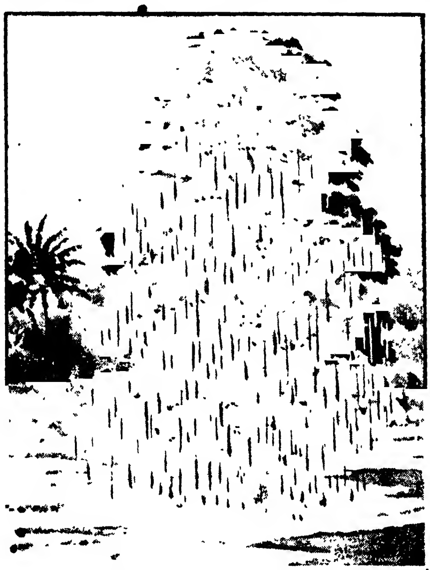
Carnivorous Plants. While parasitic plants live partly or entirely at the expense of other forms of vegetation, the flesh-eating, or *carnivorous plants*, have evolved arrangements by which they are enabled to feed more or less upon small animals, especially insects.

One of the most familiar carnivorous plants is the butterwort (*Pinguicula*), common in the damp patches near moorland streams and springs [83]. The flowers are something like those of violets, and rise from the centre of a rosette of pale-green leaves, which, being slippery to the touch, have given rise to the popular name. On the upper sides of these leaves, near their margin, are a large number of peculiar hairs, which pour out a sticky fluid. Should a small insect be so unfortunate as to settle on some of these it is held fast, and the sensitive margin of the leaf curls over it. The fluid possesses digestive properties, and reduces parts of the body of the victim to a solution, which is absorbed by the leaf as food.

Associated with the butterwort we often find the sundew (*Drosera*), which is a still more deadly foe to insects, even large ones. Here, again, we find a leaf-rosette, the members of which have a remarkable appearance [84], for the rounded or, it may be, oval leaf-blade is studded with reddish tentacles, shaped like pins, upon the tips of which glisten drops of fluid—hence the name "sundew." This fluid, however, is not dew, but a sticky digestive fluid which exudes from the ends of the tentacles and serves the same purpose as the fluid in butterwort.

Venus's Fly-trap. Venus's Fly-trap (*Dionæa*), is a North American relative of the sundews, possessing leaves which are specialised into a peculiar kind of capture apparatus [85]. Each half of the leaf-blade is fringed with long spines, and upon its upper surface are three sensitive hairs. If an insect is unfortunate enough to touch one of these, the leaf rapidly folds up, and two sets of spines interlocking so as to render escape impossible, a digestive fluid is now poured out from minute hairs which stud the surface of the leaf, and the last act of the drama is as usual.

In the pitcher-plants, of which numerous species inhabit the warmer parts of the globe, we find that the leaves are modified into variously shaped receptacles which prove fatal to many insects [86]. These are attracted by the colour of the pitchers, which are commonly blotched with purple, and also by a sweet fluid secreted in the neighbourhood of their mouths.



90. WEEPING TREE

The small organisms which swarm in fresh water are not altogether spared by carnivorous plants. In bladder-worts (*Utricularia*), for example, parts of the leaves are swollen into little rounded traps [87], each of which has an inwardly opening door.

Influence of Water in Plant Life. A large amount of water evaporated from the leaves and young stems of plants is a process which is known as *transpiration*. A plant which has a large amount of water at its disposal transpires to a corresponding extent, and also possesses arrangements by which superfluous moisture is prevented from accumulating upon it. Such a plant is termed a *hygrophyte*. If, on the other hand, the water supply is scanty or difficult to absorb, transpiration is checked by various devices, and there may be arrangements for storage of liquid. Conditions of the kind have led to the evolution of *xerophytes*.

It has been proved experimentally that many plants alter completely in appearance if the water at disposal is varied in amount. A good case is that of the gorse (*Ulex Europæus*) [89].

Some leaves are able to get rid of water in the liquid form, generally at or near their edges. This is the origin of the drops of liquid which may often be seen sparkling on Indian cress (*Tropæolum*) and lady's mantle (*Alchemilla*) [88]. In tropical forests transpiration goes on more rapidly as soon as the sun rises, and the water vapour condenses into a sort of fine rain. The so-called "weeping tree" (*Cæsalpinia pluviosa*) is a notable example [90].

To be continued

Continued from page 399

THE USE OF THE SHOP WINDOW

The Mission of the Window. Importance of a Central Idea. The Danger of Overdressing. Colour Harmony. A Useful Colour Scheme

By W. B. ROBERTSON

The important subject of the arrangement of window display—window-dressing proper—comes up for consideration. Many shopkeepers place too little value upon their windows. But they seem to be learning wisdom. We do not see so frequently as we formerly did that retailers have allowed some enterprising firm of soap or patent food manufacturers the monopoly of their windows for a stipulated time. The window is the most direct, valuable, and practical method of advertising at the command of a shopkeeper, and he should use it accordingly.

Mechanical Attractions. The sole object in window-dressing should not be to draw crowds. It is possible to draw crowds that will not do the shopkeeper any good. Mechanical figures used to be common in some shop windows. Their value was questionable. It was certainly overestimated. A tumbling figure or a dancing doll is not a business-bringing attraction in a shop window unless the automaton has some direct relation to the article advertised by its agency. The figure of a prim white-capped waitress bearing a tea-tray and a teapot, for example, is an extremely appropriate "draw" to sell a special blend of tea. There must be appropriateness between the article to be sold and the medium of selling.

Figures in motion always command attention. If they are particularly clever or appropriate they impress. There is a shop in London where the thorough appropriateness of a mechanical device may be seen. The article to be sold is a food chopper, and the maker wishes to impress the public with his claim that the machine will chop anything edible. A procession of tiny figures of ducks, geese, rabbits, pigs, oxen, fish, bread, vegetables and fruit moves on an endless band into the hopper of one of the choppers and emerges at another part of the apparatus to continue the round again. Other instances might be cited, but none more telling than this.

The accessibility of the window contents is a point which has been already urged. Our illustration reproduces a prize provision window at the recent Grocers' Exhibition, and shows how this accessibility may be secured. This window may be taken as typical of what a well-dressed provision window ought to be. It is not crowded to excess, the arrangement is good, and there is nothing that could not be conveniently reached and withdrawn.

Window Pricing. It is a disputed point among many retailers as to whether a system of window pricing is remunerative. The practice may claim this in its favour, that the most prominent and most successful firms adopt it, and many of them have built up large businesses chiefly through its agency. Nothing should be priced in a window which will not bear scrutiny and comparison. Many purchasers wish to know prices before they enter to buy a coveted article. Others like to compare prices in various windows before deciding who is to have their custom. Such purchasers the shopkeeper with displayed prices attracts. In these days it cannot be denied that there is in most shopkeeping departments a demand, and in many instances a necessity, for window pricing in plain figures.

Seasonable Goods. Most shopkeepers would resent the counsel that they should display in their windows only goods of a class that is in season at the time, but the caution is not always superfluous. There is, however, a complementary rule which should be observed. It is: "Emphasise season's goods." At the time of special season's goods the purchases of that class are being made for a whole year, and to refrain from making the utmost out of opportunity is to lose the chance which will not recur for another twelve months.

The manner of emphasising season's goods is by a prominent window display. The best seasonable window display that we have seen for a long time was that in the window of a London tailor a few months ago. He wished to draw attention to his shooting and sporting suits, and he put in a characteristic sporting window. His sporting suitings were well displayed, and the floor of the window was covered with heather from the hills arranged to resemble natural growth as nearly as possible. A fox lurked at the side of a roll of cloth, a deer's head protruded from one corner, pheasants and partridges, lapwing and quail, and even to the humble sparrow the feathered kingdom was represented. A gun rested in front. The whole display exhibited fidelity to one idea, a homogeneity, and an appropriateness to the season that served its purpose well. Many a city man paused on his way to his office and dreamed that he felt the wind from the moor come from the little shop window in front of him, and the message of the window was accomplished.

Overdressing. Shop windows are usually overdressed. A window may give a more effective display with half a dozen pairs of boots in it than it will do with two hundred pairs. The first lesson that window-dressers have to learn is that quantity is not essential to window dressing. The window must be considered from what it can be made to bring in, and it should be made to talk. The man who starts to dress a window without a central idea, without a mental conception of the message he intends to cause the window to express, will fail

in making a "talking" window display. The dresser of a window should go to work like the painter of a picture. He should have a clear conception of his aim—a central idea, a prominent feature—all else should be in the nature of accessories, subordinate to the main idea, emphasising it, if possible, but not robbing it of some of its potency. Let us take, for example, a bootmaker's window. There is a well-known bootmaker in London who works this central idea even into a boot window, where one might think everything bore so close a resemblance to everything else that nothing could be well emphasised and the importance of nothing modified. Yet, in this case, by the expedient of putting forward a glass shelf with a special attachment to hold one boot at a special angle right beneath the eye level of the passers, he compels attention to that boot. One may examine more closely the other boots shown, but he is not forced to do so. But that single boot is there, and one cannot get away from it. It must be noticed.

Where the business is mixed, it is not well to mix the window contents unduly. There is a shop in Dublin where one idea—not a central idea only—is carried out in the windows. The windows are dressed afresh every morning. There is only one class of merchandise, and not too many samples of it, on view at one time. One morning it may be, say, white wood articles of ornament—nothing but white wood ornaments—not crowded. On the following morning it may be brown earthenware vases and so on, one thing at a time, and that thing well shown.

Half the shop windows in our streets would be more effective bringers of business if half their contents were withdrawn, and the remaining half arranged to carry their message.

Show Remunerative Articles. No merchant finds everything he sells equally remunerative. On many articles the profit is so small that time and money would be saved if they were not handled at all. Yet many shopkeepers make displays of such things for the simple reason that there is an attractive show card illustrating them or that the containers are pretty. This is folly. The first business of a window is to earn money for the shopowner, and if the window is being made to sell the products of a manufacturer whose goods do not carry their proper burden of profit, it is being sent on a false errand. Preference should always be given to the most remunerative articles, and if there are certain widely-advertised specialties, the sale of which does not pay, a good window show of lucrative competing articles should be made.

The temptation always exists to exhibit in the window the best goods to be found on the shelves. Sometimes this is wise. Often it is the reverse. If a draper is in a neighbourhood where common articles of apparel are almost the only kind bought, it will convey a false impression of his stock if he exhibits only high-class articles. He ought to show what his customers are likely to buy. By exhibiting, say, silk blouses at 25s. each, he may sell perhaps one a week, but if he had shown articles more in keeping with the class of people by whom he is surrounded, he might have done far more business and made more money.

Assisting the Advertisement. Some retailers make a practice of having conformity between the window displays and the advertisements in the local papers. This is good. The window is then the stepping-stone between the newspaper announcement and a visit to the shop. The customer is interested by the printed page, impressed by the window, and inspired by both with a desire to examine more closely and handle the article advertised. The window may be made to supplement the story of the newspaper column, to intensify any interest aroused by reading the weekly sheet, and to this end the articles shown in the one should be those written about in the other.

Outside displays have a value, but in this country they are confined to shops of the cheaper class. In Paris and other continental towns the pavement trade, even by large and important departmental stores, is enormous. Our climate makes it impossible that we should display goods in the open as do the Parisians, and it is unlikely that it will ever become the fashion to vend soilable merchandise in this manner. Local regulations governing displays on the side-walk are also stricter in this country.

Colour Harmony. Those who aspire to make window-dressing an art and to put into that art the best work of which they are capable, will not neglect to study colour harmony. There are many departments of shopkeeping where outrage upon good taste in the colour schemes of window displays is frequently perpetrated. In the drapery, outfitting, and house decorating shops a knowledge of colour values is highly desirable. In these trades the shopkeeper must impress with his taste in the selection and arrangement of the merchandise, and how can he do so if his windows testify to an ignorance or a carelessness regarding the canons of art in colour blending? If the window-dresser has the artistic sense highly developed he already knows and appreciates the importance of colour harmony. If, on the other hand, it be a subject upon which he is comparatively uninstructed, he may be certain that many of the public whom he wishes to attract will judge him by the selection of colours placed together. The drapers' assistant who has to arrange in his window only the cheap muslins, flannels, and serges which sell to a poor working-class population may, if he choose to develop the faculty, make his windows expressive of beauty. Beauty is a passive rather than an active quality. It consists in the absence of anything that offends the sense of proportion in form or colour. It has been expressed as a proposition thus: "True beauty results from that repose which the mind feels when the eye, the intellect, and the affections are satisfied from the absence of any want."

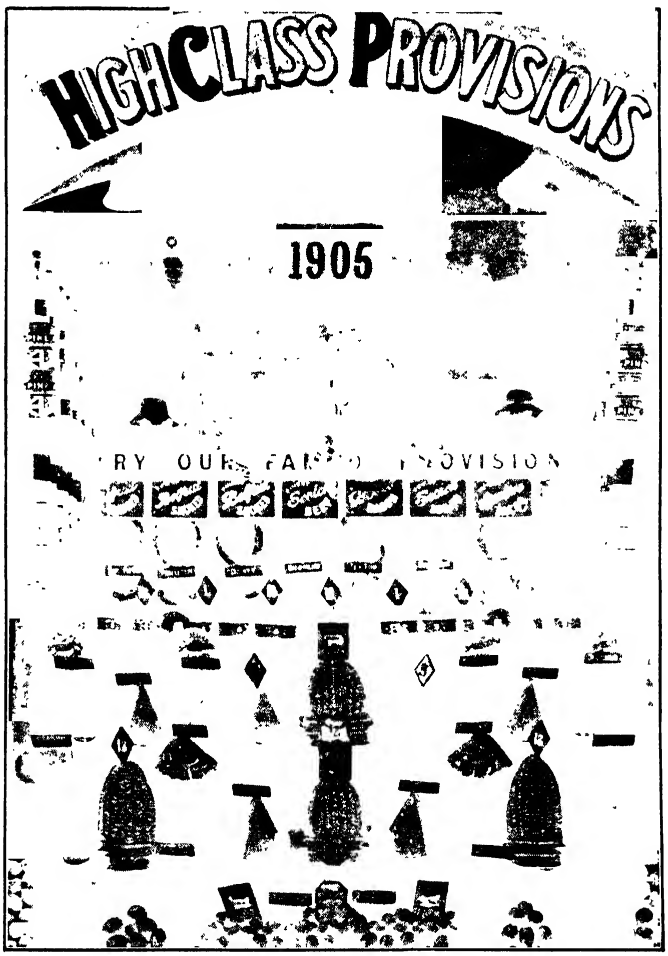
But attempts to analyse beauty of either form or colour fall a long way short of enabling us to express our meaning in exact terms. The

formulation of definite rules for combining colours so as to produce artistic effects is impossible. General rules are encrusted with so many exceptions that they lose their value as rules.

Complementary Colours. Generally speaking, *complementary* colours go well together. While we shall not here make exhaustive study of colour analysis, we may explain the meaning of "complementary colours." The sum of all colours is white. Take any colour away from white and that which is left is the complementary colour to that taken away. In the following pairs of colours the one colour is complementary to the other in each case:

Red and green; Orange and blue; Yellow and violet; Orange-red and blue-green; Orange-yellow and violet-blue; Greenish yellow and reddish violet. But although in many of these contrasts the effect is pleasing, in others it is found too hard and loud. For this reason the colours are often softened to give harmony. One authority submits the following table as a guide in colour schemes, and the window-dresser who follows its conditions will be very unlikely to offend the eye for fine colour effects.

Red and yellow	better than	red and orange
Red and blue	,, ,,	red and violet
Yellow and red	,, ,,	yellow and orange
Yellow and blue	,, ,,	yellow and green
Blue and red	,, ,,	blue and violet
Blue and yellow	,, ,,	blue and green
Yellow and orange	,, ,,	red and orange
Yellow and green	,, ,,	blue and green.



A MODEL PROVISION WINDOW
Awarded First Prize at the Grocers' Exhibition of 1905

Some Rules for Window-dressers. There are several other ascertained facts that the designer of window displays would do well to remember. Colours on white grounds appear darker, and on black grounds lighter. When two tones of the same colour are placed together, the light colour will appear lighter and the dark darker. When two different colours are placed together each will receive a touch of the complementary colour of the other. Thus, if orange and red be placed side by side the orange will seem slightly greenish and the red tinged with blue. When ornaments are on a gold ground they should be separated from the ground by a darker edging. Gold ornaments on any coloured ground should always be outlined with black. Edgings of white, gold, or black to ornaments are usually harmonious. Ornaments in colour or gold on white or black ground go well without edging.

These may be held the chief rules that should guide the window-dresser. But, being an art, window-dressing cannot be taught like Euclid. Success demands enthusiasm. If it be true that art is the expression of pleasure a man puts into his work, there is no department of shopkeeping into which art can enter more deeply than into that of window-dressing. The mission of a shop window is to tempt. A tart in a baker's window, for example, is to him not so much an article of consumption as an agent of temptation—an allurement to cause children to disobey their parents, and invalids to disregard their medical advisers!

To be continued

Group 29 **TRAVEL** 4 Continued from page 394	# HOW TO TRAVEL ABROAD **Companionship in Travel: Its Advantages and its Drawbacks. The Different Modes of Travel. Language. Food. Money. Clothing. Economies**

By J. A. HAMMERTON and WILLIAM DURBAN, B.A.

FAR more people are possessed of the travel temperament than are conscious of the fact. Multitudes are naturally endowed with fine perceptive capacities, but have never given their faculties a chance of development. Intelligent and sympathetic people should, if possible, travel somewhat while they are still young. Very recently the daily Press reported the discovery of an old lady living in a London court who has never been inside an omnibus, and is exceedingly proud of the fact that her practical acquaintance with geography extends little beyond that narrow court. That is, after all, only an exaggerated type of a too common order of mind, developed by lack of movement about this wonderful world.

Companionship is one of the vital accessory conditions of travel. This factor must be largely regulated in accordance with idiosyncrasy. A person who is by inclination exceedingly sociable naturally shrinks from the idea of a solitary tour. But even some of the most socially genial spirits occasionally long to break loose from every conventional tie. Said a very able and busy City man not long since in our hearing: "I dearly love my family circle, and there is no happiness like that I enjoy in my own home; but when I take my little annual holiday on the Continent, I do like to go quite alone!" The reason was that this gentleman, tied all the rest of the year to his office, feels like a schoolboy let loose for the most active play when he can simply shoulder a knapsack and go climbing up mountains, or tramping over high and fatiguing passes. He would wear out those who are dearest to him by the sort of vacation he needs.

Advantage of Companionship. But fellowship in travel has its advantages and its drawbacks. It is an advantage to any tourist going forth for the first time into the great foreign field, without any knowledge of the people or the language of a strange country, if a friend can be found who is a linguist, who delights in touring holidays, and is gifted with both the traveller's instincts and with the spirit of comradeship; then the yoke is delightfully easy, and the pleasure is doubled. But it is imperative that the novice give himself to the leading of his friend. A programme—at least, a tentative one—should be agreed on beforehand, and there should be on each side a disposition to make mutual concessions by the way. We have known what should have been a most enjoyable expedition turned into an itinerating purgatory by the determination of one of the two parties to make the whole occasion, from first to last, subserve some purpose in which the other could feel no special interest. Everything had to give way to that. Where a number of people join in a party, congenial souls will unconsciously and inevitably gravitate together. This is one reason why organised and conducted parties for travel on a large scale are so popular. It is not only because facilities are arranged—though this for many people is of supreme importance—but because suitable companions are sure to be encountered, that this mode of touring is so much in vogue. If mutual temperament allows, the duet plan is a good one. Where two people are friends, who know and understand and appreciate each other, their fellowship and reciprocal help are always likely to enhance pleasure, to obviate the feeling of home-sickness, and to prevent a sensation of loneliness

The Solitary Traveller. But so much depends on individual temperament that it is dangerous to lay down rules or to give advice in any dogmatic way. One of the present writers more strongly than the other favours the lonely journey. He has experienced all kinds, and believes that, given the frame of mind which enables one to derive pleasure and profit from the common objects of a day's journey, there is no way of travel better than that of going alone; for even two friends are apt to tire each other in the course of three or four weeks' continuous companionship, than which no more crucial test of friendship can be devised. A triangular party is better than two—unless the two have been tested and tried by previous companionship—for it is well that there should be an umpire, as it were, to decide any difficulties that may arise. Husband and wife make the best couple, since they have learned the lesson of "bear and forbear" as friends seldom learn it. But perhaps the lonely journey is best when one goes afoot or awheel, the two ideal methods of foreign travel. "Now, to be properly enjoyed," says R. L. Stevenson, "a walking tour should be gone upon alone. If you go in company, or even in pairs, it is no longer a walking tour in anything but name. It is something else, and more in the nature of a picnic. Walking tours should be gone upon alone, because freedom is of the essence; because you should be able to stop and go on, and follow this way or that as the freak takes you, and because you must have your own pace, and neither tramp alongside a champion walker, nor mince in time with a girl. And then you must be open to all impressions, and let yourself take colour from what you see. You should be as a pipe for any wind to play upon." It also breeds self-reliance, independence of judgment, resource.

Pleasures of Wayfaring. Then, again, the solitary wanderer can economise if he wishes to do so; can stay where he pleases and as long as he chooses; can alter his itinerary at will; and can regulate the occupations in which he wishes to engage without fear of inconveniencing a companion. Reading and writing can be indulged in without let or hindrance; calls can be made; business can be done if there is advantage in attempting any; and either rest or extra exertion may be enjoyed individually to an extent hardly possible under the limitations imposed by company. We met a schoolmaster in the wildest solitudes of Norway, in the very heart of the grand Fille Pjeld, who was walking right across the country from Christiania to Laerdal Sören, and was carrying nothing but a rug and a knapsack. He intended to take three months for the tramp, staying as he pleased at any specially inviting spot. He had been sadly unwell at home, but the journey was putting new life into him. "I am never lonely," said he. "I get delightful little episodes of chat almost every day with strangers like yourselves." On the other hand, we recollect how, in Athens, we had long and unusually enjoyable talks with a most accomplished Belgian financier. This gentleman told how he had been three months in Greece on important business. He was entirely alone, and was accustomed to long expeditions, but had been laid up ill alone at that hotel in Athens. He had simply been left in solitude, excepting when the doctor came to see him, or the servants did whatever was necessary. The people of the place took no sympathetic interest in him whatever, and the sense of solitude had been fearful.

Husband and Wife. Of course, the ideal foreign journey is that in which husband and wife accompany each other—if both are alike fond of movement and sightseeing. Nothing in literature can be reckoned more delightful than the mutual accounts of their wanderings by Sir Samuel and Lady Baker, or Professor and Mrs. Tyndall, or Sir F. and Lady Lugard, or Mr. and Mrs. Bullock Workman, or the Duke and Duchess of Argyll (Princess Louise), or Professor and Mrs. W. M. Ramsay, or Mr. and Mrs. A. M. Mummery, or Mr. and Mrs. Theodore Bent, etc. A book lies before us which we consider one of the most extraordinary illustrations known of the special side of travel to which we are referring. It is entitled "The Collected Remarkable Travels of George Pitt, Accompanied by His Wife, Round and Over the World." Mr. and Mrs. Pitt belong to the Society of Friends. Their record shows how the world can be seen with the utmost enjoyment, on what Mr. Pitt calls "marvellous conditions of economy," by two people who are happily mated.

Family Travel. A few weeks ago a gentleman and his wife returned to England after a voyage round the world. They are unpretending, intelligent, business people—still in business, indeed—but determined not to work without knowing something of the glories of the world they live in while still able to enjoy life. They have brought home stores of pictures; have taken copious notes; are full of happiness when in conversation over their reminiscences; have made kind friends all over the world; and have spent astonishingly little considering what they have seen.

Family parties on tour, of course, involve considerable trouble and responsibility for the seniors, but these have the intense pleasure of knowing that they can in this way, as in no other, at one and the same time train young minds and impart to them indescribable enjoyment. There cannot conceivably be anything more gratifying than to watch the wonder, and often ecstasy, with which youths and maidens for the first time gaze on the view of the Jungfrau; or watch the prospect from the top of the Stelvio Pass; or look at the majestic cone of Etna; or inspect the beauties of Capri; or follow the doings of the sardine fishers at Amalfi. To minister in this way to the intellectual development and the culture of taste in boys and girls at the most impressionable period is worth considerable sacrifice.

Travelling with Specialists. Other conditions (such as those of temperament, etc., already referred to) being equal, it is specially advantageous, if possible, to secure the company of some specialist, but an expert who can convey his knowledge to the non-expert mind, and does not ride a hobby to death. On one occasion, we recollect how an expert botanist opened up a perfect world of wonders amongst Alpine flowers during an expedition which happened to be undertaken just at the best season for his observations. At another time we were for some days favoured in Italy with the fellowship of an architect who was an enthusiast in his profession, and was overjoyed to meet with sympathetic listeners to his expositions.

Ministers of religion are apt to think that there is no better idea practicable for making the most of a Continental trip than in the society of a brother minister. But we know of a minister who has for years enjoyed long pilgrimages with a Church officer who is a business expert. The former is able to give endless information on ecclesiastical affairs and history, and is considered a perfect peripatetic cyclopædia in this direction, so that a visit to a cathedral or an abbey in any country is a treat in his society. The latter is stored with knowledge on practical international affairs through his large commercial foreign dealings. Two people who are both skilled in different departments can double the profit and pleasure of a trip. We once visited Greece in company with a merchant who carries on large transactions. When we came to such places as Patras, and saw the vast heaps of currants piled on the quay waiting for shipment; when we rode that enchanting trip along the Bay of Lepanto; when we stayed among the vine-growers round Corinth; and when, on leaving Greece for Asia Minor, we went into the wonderful gardens where sultanas were ripe on the vines, it was enlightening indeed to listen to the merchant's exposition of many matters

connected with business in various commodities. We came home with stores of fresh knowledge.

But it is surprising how much information one may gather from talking with chance acquaintances. Once we had the whole interesting trade in fruit and vegetables between Brittany and England explained to us at Tréguier, where, going to visit the birthplace of Rénan, we found two English ships taking away tons of new potatoes, and got talking with the representative of the English merchants, who was staying at our hotel. People who ride hobbies are to be avoided at all costs; authors of the same class also. For instance, Mr. Percy Dearmer's "Highways and Byways in Normandy" is weighted with tiresome disquisitions on stained glass, which can only interest the specialist, and is only saved from dulness by the accuracy of its information, some good descriptive and historical passages, and Mr. Pennell's illustrations.

The Means of Travel. In these days of varied modes of locomotion, four methods of travel are in vogue. Each of these is attractive to different orders of mind; each is specially suitable for distinctive purposes, and they obviously admit of various combinations and permutations. Train, carriage, cycle, and foot must each be acknowledged to have certain preferential claims in different directions. Pedestrians and cyclists have this great advantage—that they are able to visit just what spots they wish, and as in many cases railroads and Nature in its real beauty do not nurse each other, there are countless points of attraction that are never seen by those who only travel by train. At the same time, where swift transit is desired, or considerations of physical weakness must be consulted, the railway, of course, takes the first place. The cyclist effects the completest compromise possible. He can go anywhere very quickly, and thus is most perfectly master of the situation—apart from the greater liability to accidents and breakdowns. Carriage driving is the ideal way of getting about for the valetudinarian or the elderly tourist. It is invested with peculiar delights; and for the wealthy the automobile constitutes, of course, the acme in this department. We say "for the wealthy," not because of the initial cost of the car and its fitments, but for the reason that motorists are regarded everywhere abroad as persons of longer purses than cyclists or ordinary travellers, and are apt to be imposed upon accordingly.

The Language Problem. We now approach certain difficulties which are greatly dreaded by large classes of would-be tourists. The most formidable of these is the language problem, especially as we are not a nation of linguists. The educated Russians and the Dutch far excel us here. The notion that English is practically—for the convenience of the Anglo-Saxon traveller—a universal medium, is a painful fallacy, as the tourist speedily discovers directly he ventures off the beaten Continental track. Our insular language is usually understood by some functionary or other in the chief hotels of important cities, but this is apt to be the limit. One of the most comic sides of travel has its cause in the absolute linguistic ignorance of multitudes of travellers. Two American ladies recently related to us some of their curious experiences in certain small German towns. Yankee-like, they were on a very hot day anxious to secure a water-melon. Their English was an unknown tongue to the hotel folk, so they tried by gestures to indicate that they wanted something of globular shape. A large wash-hand basin was brought, to their great astonishment, and next an open umbrella was tried, on which they were constrained to abandon their quest.

It is remarkable how very far, however, a slight smattering of French, German, or Italian will go. French is generally understood in good Italian hotels, but it is of little use in Germany, excepting in the most fashionable centres, while German and Italian are generally of no avail in France. In many parts of Switzerland, French, German, and Italian are interchangeable. It is so easy to gain a slight elementary acquaintance with any Continental language (excepting Russian, Magyar, Finnish, Basque, and Turkish) that no tourist should shun the little labour needed for a task which pays in every way. A trip in Norway or Denmark is doubly pleasant if the voyager happens to have acquired something of the common vocabulary. Norwegian is the language of both these countries, and it serves almost equally well for Sweden, the language of that country being cognate. A little Swedish will take the wayfarer nicely almost anywhere in lovely Finland. It is to be borne in mind that even little fragments and scraps of the native tongue are intensely appreciated by the people, who will generally place themselves eagerly *en rapport* with any visitor if they see he is so far sympathetic with their country and their nationality as to think it worth while to cultivate some knowledge of the language they speak.

Continental Feeding. Those who are going abroad for the first time will need the valuable hints which they can gain by consulting more experienced people as to various conditions of life in other lands. Otherwise experience may be dearly purchased. The dangers arising from insanitary surroundings were much greater of old than they are to-day. If wine is taken, it should be the native product, rather than some imported vintage. Changes of diet are inevitable in extensive travelling, but simple food will be found the safest. The average Continental table-d'hôte is excellent, as well as inexpensive. The tourist abroad must not expect to be treated to chops and steaks, or to cuts off large joints, in English fashion. The dietetic ways of John Bull are absolutely strange to all foreigners. Few people in the South of Europe ever saw a buttered slice of bread, and, for that matter, our way of eating bread is quite unknown to the ordinary American. But Continental diet has its peculiar pleasures—delicate little dishes; soups of infinite variety; compôte such as is never dreamed of

in this country; superb poultry in France, and delicious quails and bécasses further south; a continuous fruit banquet in Italy, Greece, or Turkey; luscious preparations of caviare, sterlet and sturgeon in Hungary and Russia; *pièces de résistance* of tunny or swordfish at Messina, Taormina, or Constantinople; dishes of berries like the incomparable "moltebaer" in Norway, with wonderful cream from the saeters; reindeer tongue in Finland; goose breasts in jelly, followed by pumpernickel in Germany, occur to memory as a few of the culinary attractions that are unfamiliar to the British appetite, but are likely to be truly relished by any hungry tourist as he sits down at a foreign table.

Hotel Charges. Of the charges at foreign hotels the tourist in most cases need have no fear. Excepting at the most aristocratic resorts in the height of the seasons, the charges are almost universally less than those of our own British hostelries. It is, for instance, far more expensive to stay in the Scottish Highlands than in Switzerland. Italy is cheaper still. Usually the most costly items are extra little things asked for beyond those in the cartes for meals. Invariably is it more economical to lunch or dine at table-d'hôte, for which the charge is fixed and stated. All attempts to have a cheaper meal by selecting two or three dishes will result only in having to pay as much or more than the entire table d'hôte charge for one half or less of its value. Of France especially is this true, and it applies more or less to every country on the Continent. In unsophisticated places like the little and charming cities perched in the Apennines, the towns in the east and the south of Sicily, in Corsica, in the hotels of the interior of Norway and Sweden, the fees for lodging are fabulously low.

Money. Another of the popular fallacies is that "English gold will take you anywhere in Europe." This is no more true than the companion fiction about the English tongue. We have proved its falsity too often, and to our financial loss, to allow any novice to entertain it for a moment. Even so near at hand as along the coast of Brittany we have met innkeepers who had never seen an English sovereign, and who, we ascertained beyond doubt, were not emulating the innocence of Ah Sin. Also it is important not to leave one Continental country with much money bearing the stamp of another Government in one's possession. Belgian, French, Swiss, Italian, and Greek coinage is, with some reservations, current in any of these countries, but not the paper, and we recollect our difficulty in discharging a bill at a sleepy town near the French northern frontier because we had practically nothing but Belgian paper money and English gold in our possession; yet Belgium was only a few hours' cycle ride away. In the banks of most large towns there is no difficulty in changing English money, or one's hotel-manager will often be ready to supply change; but in shops and restaurants, at railway stations, and *everywhere* in the smaller towns and villages, the money of the country should be presented. It is thus important to carry a good supply of the currency, even if one has to get what is left exchanged on returning to England.

The Custom-house. The traveller must be prepared at any moment to submit to the irksome inspection of the Custom-house officers. In Tyrol this is exceedingly tiresome, because on almost any trip in that lovely region we are crossing the borders of not less than three nationalities continually. But the "douaniers" are almost universally extremely civil if they are treated patiently and courteously; if not, they will probably resent the behaviour shown them by turning out all the belongings of the wayfarer. "Pflicht ist pflicht" (duty is duty), said an Austrian Custom-house officer to some impertinent and impatient Britishers. That was a nice little play on words! The travellers were in that case compelled to pay toll on certain articles which would otherwise have escaped notice. Spirits, scents, and articles of certain categories easily ascertained, are taxed, with, of course, cigars. Only the travellers who resent the inspection of the officers—who are merely discharging their duty—ever have cause to be annoyed by the Customs.

Clothing. One of the most prevalent mistakes of those who undertake a tour for the first time relates to clothing. It is an error to imagine that overcoats or any description of warm wrap will never be needed in a southern country. The difference of temperature at different altitudes is remarkable. Nights are often very cool in Switzerland and Italy. Especially is the weather very deceitful on the Riviera. In that delightful winter resort it is dangerous to be much in the shade in light clothing, however warm and radiant it may be in the sunshine. But many changes of clothing are not needed on an ordinary tour for either sex. With reason, the smaller quantity of apparel carried about the better. Umbrellas and macintoshes should be carried, for there is frequently a great trouble to get clothing dried. Throughout very large regions of the Continent a fire, in our kitchen or parlour sense of the word, is altogether unknown, little charcoal stoves being the only means of heating and cooking. Overheating and undue exertion have caused many a valuable life to be sacrificed on tour.

The one *sine quâ non* for the tourist is courtesy. The British and the refined Americans are cordially welcomed all over the Continent, but certain samples of Anglo-Saxondom every season do their best to render themselves obnoxious to the foreigner. We have travelled far and wide in Russia, just where Englishmen are supposed to be anything but welcomed, yet nowhere in the world have we been the subjects of greater kindness from all classes.

To be continued

Group 5
CHEMISTRY
4

Continued from page 402.

THE GREAT DIVISIONS OF CHEMISTRY

Organic and Inorganic Chemistry. Chemical Formulæ. The Elements, with the Atomic Weights and Symbols

By Dr. SALEEBY

Divisions of Chemistry. When we come to consider the details of chemistry we find that the whole subject may be divided into two great parts—Inorganic Chemistry and Organic Chemistry.

Those terms, though very widely employed and very useful, are open to very grave misconception. They are meant to imply that chemistry may be divided into the chemistry of bodies that are not alive on the one hand, and the chemistry of living bodies on the other hand. But before we proceed to accept these terms, we must ask ourselves how far the supposed distinction between the two kinds of chemistry is valid.

Is it the case that, when we deal with bodies that are not alive, we make the acquaintance of a certain series of substances and can discover a certain number of laws; and that when we come to deal with living bodies we find a different set of substances and a different set of laws? At one time it was thought that such a real distinction obtained, but that belief has been modified, first in one direction, then in another, until finally there remains not a single phase of it that can be sustained. There is absolutely no distinction between organic chemistry and inorganic chemistry, save merely for convenience. It used to be thought that fundamentally different substances were found in living matter, and that it had fundamentally different properties from those of non-living matter, but no chemist now maintains this belief.

Chemical Change in Living Matter. It was long held that certain compounds were produced through the agency of life, and could be produced by no other means. That belief received a severe blow in the year 1828, when it was found that a substance (urea) hitherto thought to be a result of vital activity alone, could be artificially produced in the laboratory by the chemist. The laws of chemical change in living matter are absolutely identical with those displayed in inorganic or non-living matter.

As we have said, the distinction between organic and inorganic chemistry is purely one of convenience. Therefore, in recent times it has been sought to make the distinction on rather different grounds. When it was found, for instance, that the combination of carbon and oxygen produced carbonic acid both in a fireplace and in the living body, and that the facts and laws of the combination were precisely the same in both cases, it became obvious that the absolute distinction between the chemistry of life and the chemistry of non-living matter could not be maintained. So nowadays the term organic chemistry has fallen into disfavour, and a new term has been employed, which, indeed, appears to convey no suggestion of the old one. Instead of talking of "organic chemistry," we speak now of the *chemistry of the carbon compounds*, and the subjects which were once discussed under the old name are now discussed under the new.

An Arbitrary Arrangement. It may be said that, after all, this new term is no better than the old one, for is not carbonic acid a carbon compound, and do we propose to treat it under the heading "Chemistry of the Carbon Compounds," or are we to treat it in the earlier part of our study, or in both? It is in order to note this objection that we have chosen the illustration of the union of carbon and oxygen. It demonstrates that our distinction between inorganic chemistry and the chemistry of the carbon compounds is in reality just as artificial as the old and untenable distinction between inorganic chemistry and organic chemistry. In other words, this classification, like all other classifications, is really an arbitrary arrangement made for the convenience of human thinking and without any basis in Nature, which is not a jumble of things mixed up for us to reduce to order, but is in reality a "flawless unit of fact."

If we clearly understand that there are not two chemistries, but one chemistry, and that the laws of chemistry, in so far as they are true at all, apply equally to the chemical processes in a fireplace, or a retort, or the human brain, or the leaf of a plant, or the interior of the furthest star—we may proceed to consider what, for convenience, we term *inorganic chemistry*, not forgetting that what is true of inorganic chemistry is true of all chemistry.

Elements and Compounds. We have already seen that chemistry, as distinguished from other sciences that study matter, depends for its existence upon the fact that matter is of different kinds, and obviously it becomes the first duty of the chemist to sort out all the different kinds of matter, to give them names, to find out how many they are, and the relations between them. The name that has been agreed upon to indicate the different kinds of matter is the word *element*.

There is a child's game which has taught us all that the ancients believed in the existence of four elements. Aristotle taught that there were four elementary substances—Earth, Air, Fire, and Water. Since his day the idea has undergone great elaboration and improvement. It was Robert Boyle who first attempted to use the word in a strictly scientific sense. He said that we must apply the name element to those substances which are incapable of being split up

into simpler substances. Such substances as are capable of being split up we must call *compounds*. They are compounded of certain elements; and thus every substance that can be named or imagined must be either an element or a compound. Now chemistry has lately learnt that the elements are related to one another in such a fashion as to teach us that not a single one of them is really elementary.

The simplest element we know is really a very complex compound of something still simpler. This discovery is of such tremendous importance, in theory and in practice, to the philosopher and to the man of action, that for some time past the writer has never used the word element in its chemical sense without quotation marks to indicate that the meaning usually attributed to the word cannot be sustained, and that its use is retained only for convenience. However, when we come to look up the derivation of the word, we find that it is disputed. Some etymologists think that it is really derived from a word meaning "to grow." Others think that it means a spirit or angel, and others that it means what has an independent power of motion. At any rate, we may take it that the proper meaning of the word does not necessarily convey the idea that the substance to which it is applied is incapable of being resolved into any simpler substance, and therefore, in the present section, the word element will be freely used in its chemical sense without quotation marks, it being assumed that the reader will persistently bear in mind the fact that the meaning of the word element which has been accepted since the time of Robert Boyle can no longer be maintained.

But the reader will insist that Boyle's definition of an element has broken down, and therefore he will ask: Are there any facts left that render it necessary to use any such word at all? Now, indeed, there are such facts, and they must later be considered. For the present the reader must accept the assertion, which there is no difficulty in believing, that matter can be reduced to a number of different substances, each of which is incapable of further analysis by the chemist, and which we agree to call elements.

It will be useful if the student is presented here with a list of the known elements. The following list omits not a few about which we have yet attained no certainty, but it includes the most recent discoveries, in so far as we may regard them as confirmed. Opposite the full name of each element is placed the symbol or abbreviation which is used to express it in chemical language, and next to the symbol is placed a figure which states what is called the *atomic weight* of the element. This term is considered below.

Name	Symbol	Atomic Weight	Name	Symbol	Atomic Weight	Name	Symbol	Atomic Weight
Aluminium	Al	27	Hydrogen	H	1	Ruthenium	Ru	102
Antimony (Stibium)	Sb	120	Indium	In	114	Samarium	Sm	150
Argon	A	40	Iodine	I	127	Scandium	Sc	43
Arsenic	As	75	Iridium	Ir	193	Selenium	Se	77
Barium	Ba	137	Iron (Ferrum)	F	56	Silicon	Si	28
Beryllium	Be	9	Krypton	Kr	81	Silver (Argentum)	Ag	108
Bismuth	Bi	208	Lanthanum	La	138	Sodium (Natrium)	Na	23
Boron	B	11	Lead (Plumbum)	Pb	206	Strontium	Sr	87
Bromine	Br	80	Lithium	Li	7	Sulphur	S	32
Cadmium	Cd	112	Magnesium	Mg	24	Tantalum	Ta	183
Caesium	Cs	133	Manganese	Mn	55	Tellurium	Te	124
Calcium	Ca	40	Mercury (Hydra-			Terbium	Tb	160
Carbon	C	12	gyrum)	Hg	200	Thallium	Tl	204
Cerium	Ce	140	Molybdenum	Mo	97	Thorium	Th	232
Chlorine	Cl	35	Neon	Ne	20	Thulium	Tm	171
Chromium	Cr	52	Nickel	Ni	59	Tin (Stannum)	Sn	118
Cobalt	Co	59	Nitrogen	N	14	Titanium	Ti	48
Columbium	Cb	94	Osmium	Os	195	Tungsten (Wolfram)	W	184
Copper	Cu	63	Oxygen	O	16	Uranium	U	240
Didymium	Di	142	Palladium	Pd	105	Vanadium	V	51
Erbium	Er	166	Phosphorus	P	31	Xenon	Xe	128
Fluorine	F	19	Platinum	Pt	195	Ytterbium	Yb	173
Gadolinium	Gd	156	Potassium (Kalium)	K	39	Yttrium	Yt	90
Gallium	Ga	70	Praseodymium	Pr	140	Zinc	Zn	65
Germanium	Ge	72	Radium	Rd	225	Zirconium	Zr	91
Gold (Aurum)	Au	198	Rhodium	Rh	103			
Helium	He	2	Rubidium	Rb	85			

The above list is as reasonably complete as can be. It doubtless contains errors. There are doubtless omissions which can be predicted, as we shall see, though no known element yet fills them. As to the atomic weights there is, of course, much uncertainty and incessant re-correction. For instance, it is found that the weights agreed upon in 1904, and known as the international atomic weights, differ slightly but very frequently from the weights given by Mendeléef in the same year. Many of our chemists spend their whole time in attempting to re-determine the usually accepted atomic weights.

Errors in Calculation. *In the course of such re-determinations it has often happened that curious but persistent errors appear, and it has often been found that these errors are really due to the intermixture with the element in question of another element hitherto unknown.* Many new elements have been discovered in this fashion, and doubtless the discrepancies between the atomic weights given by one authority and another will in many cases be explained in similar fashion. One authority has used one method and one another, and the difference in their results is due to the circumstance that the two methods involve slightly different factors, one of which may well be the intrusion of a new element which alters the result in the one case as compared with the other.

As a rule round numbers have been given, and it is a fact of great significance that in many cases the numbers are really round, but in other cases it is, of course, possible to calculate the atomic weight to several places of decimals. In these cases it becomes a question to determine how far it is worth while pursuing the calculation —that is to say, at what point the figures cease to correspond to the facts of nature and come to depend upon merely the errors which are inseparable from even the most delicate and skilful experimentation. But the reader must not fancy that these atomic weights are arbitrarily decided upon, or that much guesswork enters into their composition. Suppose that no two observers get the same result. It does not follow that we cannot obtain a result which is nearer the truth than any result obtained by any one observer. Suppose, for instance, we take the atomic weights reached by a thousand different observers, and then take the average of the thousand calculations. Plainly that result is likely to be very near the truth.

No more suitable place than this could be chosen for commenting upon the study—which has lately been reduced to a science—of the limits and the laws of experimental error, and of all the factors that enter into what is often called the *personal equation.* This study is of especial importance to the chemist, whose experiments are so delicate and whose principles depend for their discovery upon the delicacy and accuracy of countless processes of weighing and balancing.

Atomic Weights. Another point may be noted as to the atomic weights of the foregoing table. It will be noticed that the weight of hydrogen is given as 1 and the weight of oxygen as 16. Hydrogen is the lightest known element, and when tables of atomic weights first came to be constructed, it was agreed to use hydrogen as the unit and to measure the weights of all the other elements relatively to the weight of hydrogen. Near the beginning of last century it was suggested that perhaps the hydrogen atom is the true unit of matter, and that the so-called atom of oxygen really consists of 16 hydrogen atoms, carbon of 12, and so forth. This could only be assumed by simply ignoring the decimal figures following the whole numbers, on the assumption that they were due to experimental error; but we know that they were not due to such error, and the simple and attractive theory that the atoms of all the other elements are simply compounded of the atoms of hydrogen cannot be maintained.

Relative Weights. If we take the atom of hydrogen as 1, then the atom of oxygen is not 16, but 15·879. That is very well established. Suppose, however, instead of calculating all our atomic weights from the atomic weight of hydrogen as 1, we allot the number 16 to be the atomic weight of oxygen, and then calculate all other atomic weights relatively to the weight we have assigned to oxygen. Then we shall have to write down the atomic weight of hydrogen not as 1, but as 1·008, and we do not appear to gain anything from this change.

But when we come to calculate all the atomic weights on this ratio, we find that we do gain substantially by allotting the round number 16 to represent the atomic weight of oxygen. We actually find that some 20 of the atomic weights thus calculated are whole numbers even to the second decimal place, and that 17 are very nearly whole numbers. This is of course as much as to say that there is a relatively simple and close ratio between the weight of oxygen and the weight of a very large number of other elements. So striking is the degree of simplicity of this ratio, far more simple than can be accounted for by the laws of chance, that it cannot but have a meaning into which we must soon inquire.

It is often thought desirable in chemical textbooks to discuss at this stage the main facts as to the characters of the elements and the manner in which they are prepared; but in writing this section in the light of the work of the last three or four years, we shall defer the consideration of such facts as the characters of the elements, and proceed immediately to a discussion of the deeper meaning that can now be discerned in the study of such a table as we have given on the previous page.

To be continued

Group 17
IDEAS
4
Continued from page 378

IDEAS FOR BUILDERS AND ENGINEERS

New Projects in Building and Machinery. Difficulties to Face and Reforms to Effect. Some Inventions in the Making and Others to be Sought

By ERNEST A. BRYANT

The Engineer of the Future. The present is an interesting and important time in the history of building and engineering. Young men about to enter upon their careers may be destined to share in notable reforms which are even now taking shape. Men in whom pride of race is by no means lacking, in whose constitution pessimism holds no place, tell us that the first need towards rendering British engineering more efficient is the institution of a monster scrap-heap, upon which to throw antiquated and ineffective machinery, whose place shall be taken by appliances more in keeping with modern requirements and with the productive skill of the nation.

The engineer will, in the future, be more closely associated with the builder. The day is about to pass when bricks and mortar and huge blocks of stone play so commanding a part in the construction of great buildings. The genius which converts waste slag into a brilliant illuminant, and a by-product from coal into medicines, scents, and dyes, representing many millions of money, will be summoned to aid the contractor to construct great works cheaply and expeditiously by means not hitherto seen in this country.

Building Regulations. But there are difficulties in the way. An Act of Parliament of the greatest value to London is the London Buildings Act. It is the Act which declares how a builder shall build, and of what. Properly speaking, it applies only to the London area, but its influence is over all the land. In minor particulars, the requirements of provincial regulations may differ, but for all practical purposes the London Buildings Act is the model upon which all are framed. These Acts, though necessary and advantageous in the main, are often hindrances, restricting the architect, builder, and engineer to old methods, and barring out the introduction of the newer methods at their disposal. Hence the day of the steel-framed building, with the innumerable possibilities of ferro-concrete, or reinforced or armoured concrete, as it is also called, has yet to dawn in this country.

Our foremost builders, architects, and engineers wait with impatience for the removal of existing restrictions. Under the existing regime it is not possible to build more than one floor at a time; with the steel-framed building, half a dozen floors may be constructed simultaneously in perfect safety. The terrors of the Employers' Liability Act make it certain that the masters will not voluntarily involve risk of injury to their men; but until the existing law is modified we must continue to build upon the old plan of one floor at a time.

Steel in Buildings. Again, we have yet to look to the time when our regulations will take cognisance of the strength of steel in a building. At present the law says that if a man put a steel framework about his factory or machine shop, not only shall he build up floor by floor, one at a time, from the basement, but that he shall put into the steel-framed building just as great a thickness of brick—all the way up—as if the steel were not there. Furthermore, though reinforced concrete is stronger than brickwork, we have at present, if using it for a building, to put in a greater thickness of it than if it were brick.

Reinforced concrete, as the student will learn from other portions of the SELF-EDUCATOR, is concrete solidified about girders or rods of steel. The steel takes the tension, the concrete the compression. It is not new. Napoleon Bonaparte employed it for his fortifications; but, like many other wonderful inventions, it has had to be rediscovered. America, which carries out building operations on such a gigantic scale, employs it for some of her largest undertakings. Some of her great buildings consist—from basement to roof—entirely of this ferro-concrete. In them enormous masses of machinery are handled, and mighty cranes travel with their giant loads every hour of the day and night—conclusive evidence of the stability of the material.

Materials of the Future. Here, then, are two directions in which the builder and engineer of to-morrow may expect to turn. The uses to which reinforced concrete may be applied are beyond enumeration. For foundations of great buildings, for sub-aqueous piers and piles, for fireproof floors, for party walls, for, in fact, every kind of building in which strength and durability are demanded, steel and concrete are the materials of the future.

The growing demand for cheaper and better cottages, which arises not only in London and the big provincial cities, but also in the country villages all over the land, directs attention to an unlimited field for the future. The problem to be solved is worthy the attention of the most thoughtful. In London, at any rate, rock-bottom seems to have been reached in the cost of production. Land is so costly and materials so expensive that if a man is to build a house which is to do him credit he must charge an exorbitant rent. The further settlement of the London artisan in cottages in or about London itself seems impossible. If he must be in London, he must seek the tenement dwellings. The best of these are as yet far from ideal. They want more air; they want more sunshine; they need better systems of heating and ventilation. Here is a

task for the accomplishment of which the whole world waits. Not even the ingenious American builder has reached finality in heating and ventilation. His hot-water pipes make the air stuffy; his ventilation simply means an apartment where draughts whirl in chilling blasts.

New materials are needed for cottages outside London. Reinforced concrete may have something to do with the solution of the problem. But the builder is still seeking a permanently non-inflammable wood. He needs it for the cottage; he needs it still more for the large establishment. The authorities, rightly holding human life as more to be regarded than the pocket of the builder, insist that wood for staircases and what not shall be of oak, or some other equally hard wood. This costs three times as much as deal, which, were it rendered really non-inflammable, would answer as well.

A Cheaper Power Supply. Another of the newer tendencies in modern industry is for great city firms to establish works beyond the London radius. Subsidiary industries spring up around these new centres of work. Populations grow and need to be catered for on the spot. Cheap mechanical processes for the small man are necessary. Here occurs the opening for economical power-supply. Hitherto, the small man has had to be content with an engine driven by steam or the gas used for ordinary illuminating purposes. The latter, handy for rapid starting of small engines, has, in its old form, done good service, but may now have to be modified to conform with newer ideas. Pressure-producer gas answers well for anything over 150 h.p., but suction-producer gas is the best servant of the smaller man, who requires up to 150 h.p. The principle of this wonderful invention is explained elsewhere in the SELF-EDUCATOR. Here it suffices to say that the gas-engine, by drawing air through a fire of anthracite coal or coke, makes its own gas as it requires it. No steam-engine is required; neither boiler nor chimney. It produces neither smoke, tar, nor smell. With a generator, a vaporiser, one or two scrubbers, and a fan for starting, the apparatus is very compact and simple. It consumes on an average 1 lb. of coal per brake-horse power, which is about half the consumption of a good steam boiler, and produces 1,000 cubic feet of gas for one penny.

How a Railway Lost a Fortune. From this, the next step will be the application of the principle to the gas-engine. Probably hundreds of minds in various parts of the world are now concentrated on this fascinating problem. Many obstacles will disappear with its advent. It is certain some day to be invented—as certain as that stars whose discovery the astronomers predict years before they are seen do eventually come within the view of the telescope. Perhaps the secret has already been solved, and needs but rediscovering. Nothing is new, save application. Professor Adams, whose valuable course on Materials and Structures appears in this work, supplies in his own experience a most interesting example of this idea. As a boy, employed in the offices of a great engineering works, he designed a new funnel for railway locomotives. He showed it to a relative who was locomotive superintendent to a railway company, but nothing was done with it.

Five-and-twenty years later Mr. Adams stumbled across his boyish production. He showed it to another relative high up in the railway engineering world, and this time the plan was adopted, the funnel being placed upon the engines of the London and South Western Railway Company. The result was, that during the next seven years the Company made a saving in fuel of £60,000. Had it been employed when first thought out, twenty-five years earlier, they might have been the richer by a sum which a child can calculate. Perhaps, in the same way we shall have to rediscover an old scheme and adapt it to the turbine gas-engine. That, says the scientist, will be the climax in the career of the gas-engine. But, as we all know, there is no finality in invention.

Railway Revolutions. Railways must always afford scope for the inventive mind. The mono-rail appears to some the plan upon which progress in the future will be made. But no man need fear that one system will monopolise the world. It is perfectly safe to speculate with new contrivances for making even our present system more up to date. Scientific railway work has an immense future. In Great Britain and on the Continent, where such vast sums have been sunk in the existing systems, revolutions cannot be immediately expected, but inventors associated with firms which are building the railways of new lands have fine scope for new ideas in traction, in appliances for giving additional safety, speed, and greater comfort in travel. Incidentally, of course, bridge construction and repair come within their purview. For their purposes, as for the purposes of a thousand other enterprises, we want more highly specialised machinery for tools; new processes for high-speed steels; more modern and powerful machinery for pressed-steel car bodies for railways. The tendency here is more and more towards sub-division, and the increasing use of machinery for producing the materials required. Any new idea which enables a tool to make faster and deeper cuts adds to the common sum of production, and may mean a fortune to the man who devises it.

Expanded Metal. It is interesting to trace the unexpected directions in which a new scheme radiates. A modern production, known as expanded metal, is obtained by punching short slits in sheets of metal and stretching out the latter into a species of trellis-work. Originally designed as a substitute for wire netting in fences, it was seized upon as the very thing to reinforce concrete employed for certain purposes. The concrete sets in the interstices of the steel and forms an almost unbreakable block. For plastered walls, the expanded steel still has its future, but for the other purpose it has become vastly more important.

The last word of the electrician has not been spoken in connection with railways. Even in

the relatively unimportant matter of bell-hanging, or the fixing of other forms of alarms upon trains, he is still far from his goal. In the matter of cliff and mountain railways there remains a vast field still practically virgin soil, while our canal system appears at last likely to claim the notice which it has long deserved but been denied.

Scope for the Electrician. Mention of electricity leads necessarily to the telegraph and telephone. The telephone will become as essential a part of household equipment as a bell or a door-knocker. Already St. Martin's-le-Grand traces a movement towards the substitution of the telephone for the telegram. This tendency they expect to see vastly developed. Necessarily, then, there lies here an enormous industry in the manufacture of implements for the telephone. Every year we pay to the United States and to Sweden hundreds of thousands of pounds for telephonic apparatus. It was but yesterday, so to speak, that attention was first given to the manufacture of these things in our own country. Now, however, that the work has actually commenced in England, great possibilities open out to the inventor. Villages lying off the beaten track of the railway companies have now their telephone stations. The convenience would be enormously enhanced could defects in the apparatus be instantly repaired. At present, however, a fault may have to lie for days, until an operator, responsible for too large an area, can attend to the breakdown. We may hope for the day when the Government will see the wisdom of issuing licences to the local electricians to undertake repairs. This in itself might mean an appreciable addition to the income of the small tradesman in the country district.

Machinery for Shops. The revival in London of a long-lost pneumatic tube anciently employed to despatch mails from the General Post Office to one of the railway termini is certain to give an impetus to this method of transmission. The pneumatic tube is already largely in use in post-offices and newspaper offices. It is capable of adaptation to the requirements of many large warehouses and other business premises. The matter of shop and business fittings has not received in this country nearly so much attention as its importance merits. Artistically, many of our great business houses are nearly perfect. In point of utility, however, not much can be said of many of the most expensive items of their schemes. Every contrivance which saves labour and time in the conduct of business means additional revenue to the firm employing it. What may be termed shop-machinery is an industry of the future. Supposing that one buy a desk or cabinet for his office. Some alteration is necessary—new or different handles are required, or some other point in its brass furniture needs amendment. You cannot get that trifling alteration made without sending to Birmingham for materials.

From all directions comes the demand for new ideas. Some firms have what is called a Suggestion Scheme. Men in the employ of such firms, if they have an idea, communicate it to their manager, and if there be anything in it they are given either a separate sum, an addition to their wages, or some share in the profits resulting from its application. The plan cannot be too highly commended. The firm which is eager for ideas, and ready to put them into practice, is the firm for which the future holds its riches.

A Metal with a Future. Aluminium is a metal with a great future. So far, relatively few have concerned themselves with it. It can be made as hard as iron, though it is only a fourth the weight of silver. It does not corrode or tarnish, and in that respect has an advantage over all metals except gold. Its uses are infinite—for shipbuilding, for bicycles, for domestic utensils, even for decorative purposes. But although it was discovered nearly a century ago, it has never really had the vogue which it deserves. Difficulty of production has, of course, been a deterrent. But we have in our rivers and streams and waterfalls running to waste the very power which would so well produce this valuable metal.

Bunsen's efforts at the production of aluminium by electrolysis were not a commercial success. But the world has travelled far since then, and electrolytic methods have developed enormously. Not aluminium alone can now be produced by this process ; the uses of electrolysis are almost unlimited. And we are still only on the fringe of the knowledge which as yet is to be gained concerning this interesting process. Every year reveals some new direction in which electrolysis carries its disciples nearer to fortune and the world to industrial revolutions.

Opportunity of the Gas Companies. Competition between gas and electricity as illuminants has become so severe that the exploiters of both have to be continually on the alert for new ideas. It is surprising that they should let slip some of the best. One of the happiest ideas is a pneumatic gas-bracket. Instead of depressing a switch to turn on the electric light, one touches a button to raise or lower the light in the incandescent burner. The mechanism is simplicity itself, capable of infinite development where the electric light is not obtainable.

Mathematicians have need of more instruments ; corporations need workable schemes for the conservation of flood waters which now run riot in winter and leave the lands parched and dry in time of drought. Our cities need improved destructor furnaces ; households need developments of coal-gas for domestic purposes. There is a call for improved cooking-stoves and utensils ; laundries need machinery which will cleanse, but not tear, clothes, nor need the use of chemicals which destroy them. Owners of small machinery plants want a simple, inexpensive means of softening water. The printer is looking for a process by which he can print satisfactorily half-tone and "line" blocks on the same page without spoiling either.

To be continued

SLEEVES, AND THE MAKING OF A SKIRT

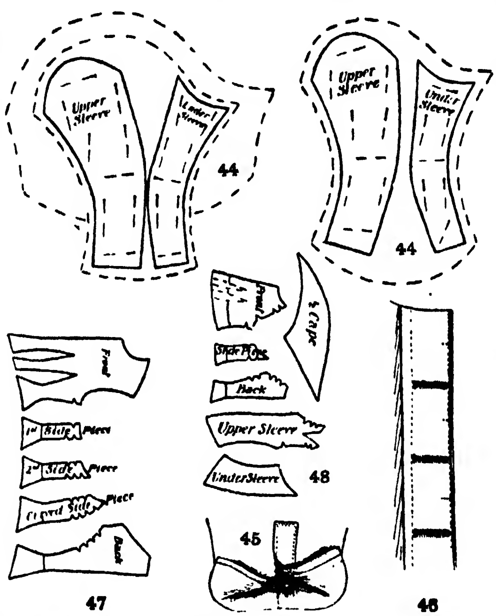
Drafting Blouse Sleeves. Making a Blouse. Bodice for Stout Figures. The Drafting and Making of Various Patterns of Skirts

Continued from page 480.

By AZELINE LEWIS

The Sleeves. So far our blouses are sleeveless, but this omission can be easily remedied by turning to the next diagram. Here we have three different shapes evolved from the coat-sleeve of our drafting—that of a gigot, or leg-of-mutton, sleeve, having been already described.

On the right-hand side of No. **44** a medium-sized bishop sleeve is depicted. Place and pin the upper and under portions of the coat-sleeve pattern in their relative positions, the space between the slope at top and cuff being regulated by the shape and size required, and cut out. On the left-hand side the method of obtaining two sleeves is shown—namely, a leg-of-mutton bishop, and a puff to the elbow. For the former, the upper and under portions of the coat-sleeve are placed farther apart at the top than in that on the right hand, and consequently closer together at the wrist. From these two examples it will be seen that it is just the space between the upper and under parts which determines the shape and size of the sleeve; the nearer together they are at the cuff part, the narrower will the sleeve be here and the fuller at the top, and the reverse, the space at the lower part, with a corresponding sweep of curve, giving the jelly-bag sleeve, which has, fortunately, just been consigned to the limbo of things past, but which may again return for aught we know.



44. LEG OF MUTTON AND PUFF AND BISHOP SLEEVES. **45.** WRIST OPENING. **46.** FALSE HEM FOR INVISIBLE BUTTONHOLES. **47.** BODICE FOR STOUT FIGURE. **48.** BODICE WITH ALTERED WAIST-LINE

The second and outer row of broken lines on the left-hand example gives the method of cutting a puff to the elbow such as that shown in *d* of the group of blouses [See last number], the cuff portion being cut to the same shape as the lower portions of the coat-sleeve. The two other shapes shown—the gigot and the medium bishop with straight cuffs—are used for the other blouses. In *b* the fulness at the wrist is just pleated over and stitched instead of being inserted in a cuff.

The Making of a Blouse. Having gone through the matter of cutting-out, we will now consider the making of a plain blouse—viz., that with the American yoke. Gather the centre of back at the top about 2 or 3 inches. Turn up the yoke edge on the wrong side, snipping selvedges to prevent puckering, and press this. Place the centre over the centre-back of blouse, then pin yoke to this at both ends, also midway between these and centre; draw up fulness to the right size, being careful not to get the gathers all in one place; tack the yoke along and machine in place, quite near the edge on the right side. Turn in and either tack or press the edges of the fronts of yoke ⅜ of an inch at least on the wrong side, and as these are on the cross, it may be as well to do so over a narrow strip of muslin to prevent stretching.

Make an inch-wide hem on the left front for a button-stand, then gather upper edges, pin each end under the corresponding ones of yoke, draw up gathers to the right size, being careful not to draw them too tight. Pin in the centre and between; arrange the gathers evenly, then tack and do the other front the same. If necessary, fit on to see that the front fulness sets well and easily, and if any alterations are required. Be careful to get both sides alike, then stitch the front yoke to blouse at the edges, and put in the facing. For this last, turn in the edges to face those of outer portion. Pin the centre-backs even over each other, pin at each end, also between, and tack across. Proceed with the fronts in the same way, then hem the facing in position, and join the under-arms by a French seam.

For the fold or pleat of right front, cut a strip about 3½ inches wide, place right side to right

edge of front, run together, press, and turn over with the centre a little outside the centre of blouse, tack down, and hem inside over the turnings. Then machine-stitch at either edge with silk. Make three or more lengthwise buttonholes in the centre of this fold, and bar well at each end, then sew the buttons on the left front to correspond, and hem lower edge; if, however, the material be rather thick flannel, it can be herring-boned instead. [See HERRING-BONING.] The waist fulness at back may be either drawn up with a "runner," or sewn to a band of waist-size, which is secured to the waist-line as far as the under-arm seam. This latter method obviates the bulkiness which is more or less inseparable with the "runner," and is certainly better for woollen goods.

The Runner. For the "runner," however, stitch a piece of tape about 4 or 5 inches in length at the centre-back of waist on the wrong side—for a casing—then work a perpendicular buttonhole at each end. Take a piece of narrow tape, long enough to go round the waist and tie in front, thread it through the casing, bring one end through the buttonhole, turn down the other end and secure firmly to the tape casing, then thread another piece of tape through from the other side, and fasten in the same way.

For the collar, if of material, turn in and tack the edges over an interlining of muslin, stitch them and secure to the neck of blouse and finish off in the same way as for bodice. If of cotton material, the collar could be interlined with a coarse linen to take the starch.

Making the Sleeves. The sleeves are joined up by a French seam, and have a wrist opening made about 2 or 2½ inches in length at centre-back. For the finishing of this, stitch a narrow fold on the upper side, make a narrow hem in the under part, and fasten off the former over the latter securely at the top [**45**]. For the cuff cut a straight piece of material 6 or 7 inches wide, fold in half, wrong side out, and stitch down each end, leaving only very narrow turnings. Turn inside out, then tack and machine-stitch once along the fold, also at each end—more if wished. Gather the wrist part of sleeve, and draw up to fit cuff. Turn down upper edge of cuff, pin to sleeve, arranging fulness evenly, then tack and machine-stitch together. Turn in the other edge, being careful to make the ends neat, and hem the inside part over the turnings. Then make buttonholes and sew on the buttons. Gather the upper edge of sleeve, pin and tack in armhole, with fulness well round shoulder, then stitch in place. Cut off the superfluous turnings and overcast neatly.

For *d* in the group of blouses, the side portions must be gathered and arranged very carefully and evenly on each side *before* tacking the back to the front at the shoulder and under-arm seams. An amateur would find it easier and safer to tack the yoke, if of thin or "stretchy" lace, to muslin or leno before arranging the side portions in place, and then cut this all away when the blouse is finished.

The back fastenings are better arranged on a false hem as shown in the diagram [**46**], but if buttonholes to show be preferred, be sure to make these *horizontal*. Hooks are also used for fastenings, but they should be of a make that will not easily come unfastened, and eyelet-holes are preferable to loops for securing them, unless the material be of a thin, loose make, when small silk loops or bars, buttonholed with silk, are best.

For the yoke of *e*, if arranged as sketched, tack the insertion on the foundation, leaving not more than ⅜ of an inch between—a trifle less is better—for the faggoting. If it is to be transparent, this is better worked on a pattern yoke of something stiff, either French canvas or brown paper, and the lace must be tacked firmly at both edges, or it will go askew in the working. As this is rounded the insertion would be better run along with fine cotton at the upper edges to draw it up to the required shape.

A Bodice for Stout Figures. Thus far our models have been built for those of normal, well-proportioned figures, but there are a vast majority who are outside these limits, and such as these usually receive scant consideration in the majority of fashion articles.

It has been already suggested that for very stout figures three side-pieces may be advisable, and in some cases three darts also. In the accompanying diagram [**47**] we have a bodice of this order, an arrangement which gives more spring and shape to each portion, and also lessens the space between each, thereby giving a more graceful effect to the bodice, the making of which has already been described.

In the next diagram [**48**] is shown a bodice with an altered waist-line—*i.e.*, shorter in front than at the back, a very usual failing in those of advanced years. The sleeves are cut and set in Raglan fashion, a method which has many advantages over the ordinary shape of armhole, particularly where there is any stiffness of the joint. The pointed cape is in addition, we think, a little smarter than the shawl usually worn, as it can be trimmed in a variety of ways. As the back would be more or less bent and rounded, the centre-back portions of bodice might be eased a trifle to the curved side-piece, but it must be remembered easing does NOT mean gathering or puckering. It may be pointed out that in this shape it is much easier to obtain a comfortable fit without any of the little pleats so often thought necessary for such figures.

DRAFTING & MAKING A SKIRT

Having learnt how to draft a bodice from measurements, the next step is the drafting and making of a plain skirt. We have chosen for this purpose a five-gored affair, of walking length, as one of the most useful skirts for both slim and stout; and, moreover, one that is capable of being easily adapted to a two, three, and seven-gored shape.

For skirt drafting, the measurements required are those of waist, hip (this is taken at the largest part of the hips), and length of front. As we have already seen, however, the perfectly

proportioned figure is rather the exception than the rule, so it may be necessary to take measurements of the back and the sides to ensure a perfectly hanging skirt, particularly in the case of stout figures, though slender ones may also need this at ention. For instance, some either sink in or are rather flat a' the back, just below the waist, a deficiency which is generally accompanied by an undue fulness of figure in front or at the hips, all of which will affect the hang of the skirt. This is of special importance in the case of skirts made either just to clear the ground, or what is known as the "trotteur" length—*i.e.*, several inches from the ground.

The measurements of the skirt in the accompanying drafting are:

Waist measure	.. ..	24 inches
Hip measure	.. ..	42 „
Length of front	.. ..	40 „

Having taken these measures, we will proceed to draft the skirt.

The Front Gore. Draw lines A to 1, the length of skirt, at the edge, so as to keep this quite straight for the fold of front.

Next draw 1 to 2, quarter of hip measure ($10\frac{1}{2}$ in.), then A to B, quarter of half waist measure, plus $\frac{1}{2}$ in. for the dart ($3\frac{1}{2}$ in. in all). Now place a tape measure on B and 2, and make 3 the length of the skirt—*i.e.*, 40 in.

B to C is $\frac{1}{2}$ in., and B to 4 measures 4 in. Curve from C to 4 for the side of front, also from 1 to 3 for the foot part of this. Lower the waist front $\frac{1}{4}$ in. from A, and then curve it up to C. Mark 5 midway between C and 3, this being of importance when putting together. [49]

Side Gore. In drafting the side and back gores, remember to draw the lines for the length of these $\frac{3}{4}$ in. or so from the edge of the paper to allow for turnings.

Make A to B half the size of waist—remember, *half* measures are taken for this—plus 2 in., which last will be taken out in the darts, and then mark C midway between A and B.

From B to D measures $\frac{3}{4}$ in.

From A to 1 is 1 in. (or a twelfth of waist measure).

C to E is a twelfth of waist measure, less $\frac{1}{2}$ in.

From 1 to F is $\frac{1}{2}$ in.

Curve from F through E to D.

F to G is $\frac{1}{4}$ of waist measure—*i.e.*, 3 in.

D to H is the same length.

Draw a line from 1 to 2 for the length of skirt (40 in.), then make 2 to 3 half of seat measure (21 in.), plus 6 in.; mark 4 midway between 2 and 3, 5 being halfway between 2 and 4, and 6 the same distance between 4 and 3.

Now place a tape measure on B, extending it to 3; draw a line and make 7 the length of skirt, then do the same from E to 4, and make I the length of skirt.

We now return to the waist, and finish the dart here. 8 and 9 are each midway between F and G, H and D. 8 to J and 9 to K are each the length of the skirt. 1 to 10 is 4 in., B to 11 the same distance.

Curve from F to 10 and from D to 11 for the sides of the gore, to shape these to the waist. Make dot L $3\frac{1}{2}$ in. from E on the line drawn from here to I; then draw lines from G and H to L for dart.

For the foot part, draw lines from 2 through J, I and K to 7. M and N are each half skirt length, that is 20 in., and correspond to 5 on front width. [50]

Back Gore. Draw line A to 1, the length of skirt, and 1 to 2, half of hip measure (21 in.). 3 is midway between 1 and 2, 4 between 1 and 3, 5 between 3 and 2. From A to B measures quarter of waist, plus $\frac{1}{2}$ in. ($3\frac{1}{2}$ in.); whilst C is midway between A and B. A and D is $\frac{1}{2}$ in. E and F are each halfway between D and C, C and B.

Now place the tape measure on B, also on 2, and make 6 the length of skirt, E to I, C to H and F to G being each the same measurements. For the foot part, draw a line from 1 to I, H and G, to 6. A to 7 is 4 in., curve from D to 7 for the side of back gore. 8 and 9 are each half of skirt length. [51]

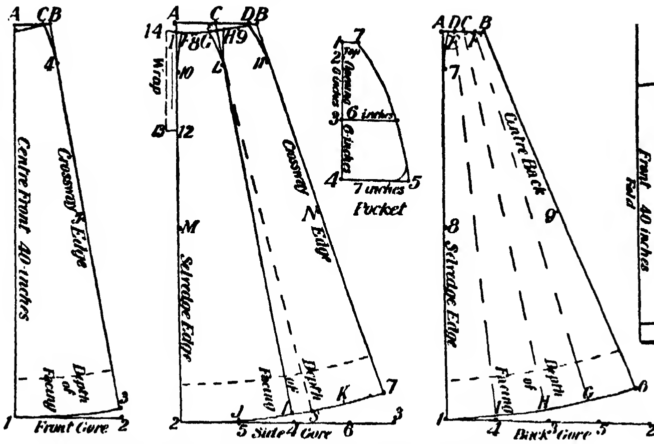
Note that the broken lines in the side gore represent the wrap for placket opening. From F to 12 is the length of placket, 12 to 13 being 2 in., 13 to E measures $\frac{1}{2}$ in. more than from F to 12, this being necessary for the curve of waist. The thick line on the wrap shows where the pocket can be inserted. This, however, is a matter for which no hard-and-fast rule can be given, as pockets can be placed in the gores, in the case of full skirts, or on the other side of the placket, to come under the front.

When the skirt is drafted, cut it out along the pencil marks, and notch the sides of the gores at the dots 4, 10, 11, and 7; also 5, M, N, and 8, so that no mistake shall be made when putting together.

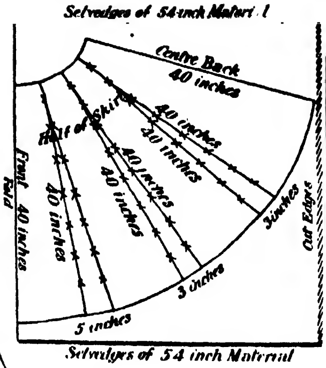
Adapting Pattern to other Shapes. Fashion is so constantly changing in the matter of skirts that we cannot possibly attempt to deal with the variations of La Mode in this respect, but will confine ourselves to showing how the more usual shapes can be evolved from the skirt just drafted. When these are done successfully, the worker should have gained sufficient knowledge to evolve any more elaborate styles that may be preferred.

The Circular or Umbrella Skirt. In the diagrams given, the portions not to be cut are marked with a line and crosses. The umbrella skirt is now a very popular shape, so we will take it first. It is cut in one piece, with a seam down the centre of back, but fashion sometimes prefers it cut in two pieces, with a seam in the centre of front as well, a method usually adopted for checked and striped goods.

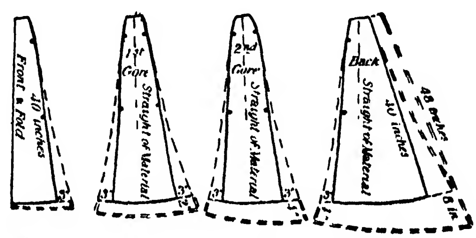
If cut in one, it is not always possible to do so from material folded in the ordinary way; but if this be opened out to its full width and then folded, it is comparatively easy. It is, however, only possible to do this when the material has no pattern or pile, as seams or joins are sometimes made on either side; and unless both are the right way of the material, the result will not be a happy one.



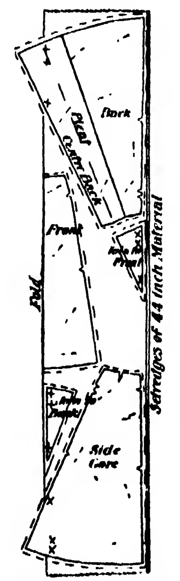
49, 50 AND 51. DRAFTING A FIVE-GORED SKIRT



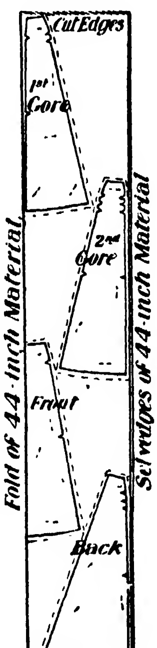
52. A CIRCULAR SKIRT



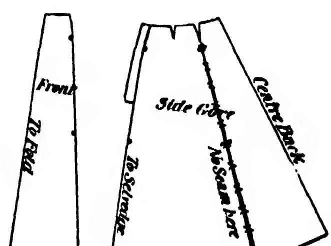
54. FLARE, OR TRAINED, SEVEN-GORED SKIRT



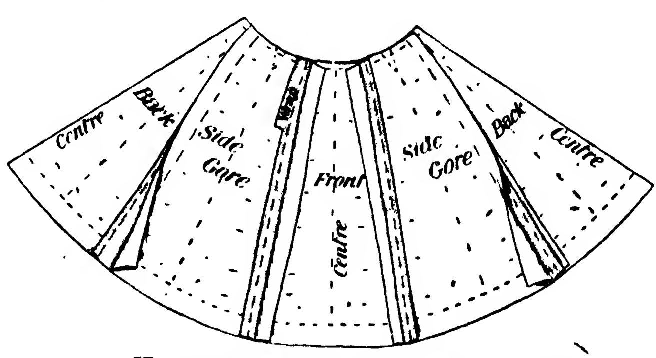
55. A FIVE-GORED SKIRT



56. A SEVEN-GORED SKIRT



53 A THREE-PIECE SKIRT



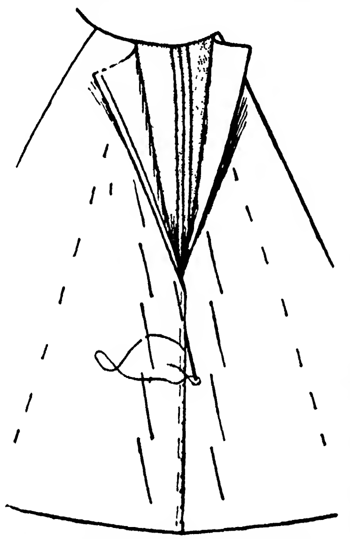
57. INSIDE OF SKIRT—READY FOR STITCHING

To convert the five-gored skirt to a circular shape, cut the side gore from I, through L, to within ½ in. of C ; this will allow it to fit closely at the waist without darts, and also give a little more spring and fulness at the lower part. If darts are required, this is not necessary. At the present moment, however, the circular skirt is very full and guileless of darts at the waist.

Having cut up the gore, open out the material to its full width, and fold over ; then lay all the gores on the material, with the centre-front to the fold, beginning at the bottom and taking care to allow for turning up. Place all the darts together, leaving a space of 3 in. or more at the bottom For a close-fitting skirt, close the darts F and C, 10 and 4 touching, which will leave 5 in. between each gore. Treat the other darts in the same manner. Pin all carefully in place before marking and cutting out. [52]

If the waist part be tucked or gathered, the darts should be placed apart. From this it will be seen that this model is capable of many modifications, and may be utilised for an ordinary morning skirt or made into an extremely stylish affair, suited to a visiting or an evening gown, when it could be trimmed in a variety of ways.

A Three-piece Skirt. This shape of skirt is also popular, and consists of a front width and two wide gores. To obtain it, place the centre-front to the fold of material, then place the side and back gores together, 7 and 11 touching, also 8 and N and 7 and 1. Mark round and cut out, excepting the portions indicated by the crosses, as in the previous diagram. The front side of gore, F to 2, must be placed to the selvedge ; and to cut this without joins the material will have to be opened out to its full width, though it would not be quite so economical as cutting from the material folded in the ordinary way and joining on small pieces at the lower edge of back. [53]



58. FELLING LINING OVER SEAMS

Converting a Five to a Seven-gored Skirt. A very graceful skirt is the seven-gored shape, particularly for stout figures, and also for a smart skirt for evening wear.

For this the following alterations are made in the side gore, so we must again refer to diagram [50].

Make S 1½ in. to the right of I, then draw a line from S to dot L—that is, just at the point of the dart, as indicated by the broken line in the diagram. Now trace from S, through L, to G at the waist, so that F to G and 2 to S now represent the first side gore. H to D and I to 7 make the second gore. When tacking together, place G to H, S and I together.

A "Flare" and Evening Skirt. From our five-gored pattern we can also evolve the "flare" skirt, either in five or seven-piece form. Our diagram shows the latter, the flare being indicated by a broken line, whilst the double line indicates the direction to be taken if a trained skirt be desired ; the length of this, of course, depending on taste and circumstances. [54] A five-gored "flare" skirt is cut in the same way.

The skirt shown in this diagram is close-fitting round the hips, but as fashion alters so much in respect to fulness, it may be necessary to cut it of ampler dimensions.

The width of the front gore is a quarter of hip measure, the two side gores quarter of hip, plus 5 in. or more, and the back, half of hip, or more, according to taste and prevailing fashion. The length, of course, will also be regulated by the same rules, as well as the flare, which may be more than the 3 in. allowed for in the diagram. When cutting out this skirt, the gores with the broken line should be placed to the straight of the material, as indicated in 54.

The Back Fulness. With respect to the fulness at the back, this is largely a matter of taste and fashion. Sometimes a sheath-like effect, guileless of any pleat at the back, is the prevailing mode ; at others a fairly full effect is preferred, which is obtained either by a box, or an inverted, pleat at the centre-back. If the former, the centre-back must be placed to a fold, as there must be no seam here. If the latter, the centre seam on the bias, as shown in the diagram [51], will be correct, but the needed amount for this can be allowed on the back of the pattern.

For stout figures, a pleat or fulness at the centre-back is always desirable, as it "takes away" from the apparent width or flatness which is so frequently the weak point.

If a gathered skirt be required, the drafting should be cut without allowing for either dart or shaping at waist part of seam—that is, from A to B in the case of each gore, plus the necessary amount for fulness, which depends on the material employed, as very thin stuff requires a good deal to look well without adding very much to the size of hips. The greater amount of fulness should be at the back part of side gore and the back gore.

Cutting out the Lining. Having traced and cut out the pattern and carefully marked the various portions indicated by the dots, we will proceed to cut out the lining.

Place the front of pattern to the fold. Trace from 1 to 3 to C, and also through 5, leaving ¾ in. on side seams, and 1 in. on the bottom for turnings. Should the material be of a loose make, 1¼ in. must be left

The front edges of side and back gores go to the selvedge If the lining is not wide enough to cut the side gore, join on pieces at the lower part of back, as shown in diagram [55]. Trace from 2 to F, through E to D, from 2 to 7, from 7 to D; also the line from I to dot L and the dart, the dart and wrap, also M and N, and leave turnings as before. Then trace the back gore.

Cutting the Facing for Foot Part. The broken lines at the bottom of the diagrams 49, 50 and 51 indicate the depth of facing, which, to set well, must be cut to the same shape as the bottom of the skirt. For the front, mark off 3 in. from the bottom, or the depth of facing required, from 1 on the fold, also in the centre and up from 3. Draw a line through these marks.

For the side gore, mark up 3 in. (or to correspond with the front) from 2, J, I, K and 7; then draw a line through marks, as explained for front. Treat the two gores in the same way; then, to save wasting the lining, trace the facing out on paper, taking care to number and mark the parts where they are to be joined.

Cutting out the Material. When the lining is cut out, proceed to arrange the various portions on the material, as shown in the diagram [55], which represents the five-gored skirt placed and pinned on 44-in. goods without any up or down, so that the back gore may be reversed, and considerable economy effected.

For faced cloth, or any material with an up and down, each gore must be placed the right way up, and no reversing is possible, as shown in diagram [56]. Velvet or velveteen will necessitate each piece being placed separately and to face the right way up of the material, in the same way as shown for bodice. [See Bodice.] Trace and mark the material in the same way as the lining, allowing the same turnings.

Basting Lining and Material. First outline the waist-line and the bottom of the skirt on the lining, also the placket opening and darts, with white cotton. Before beginning to baste, place the fold of material of front on the corresponding fold of lining, and tack the two pieces together along this line. Smooth the material carefully on both sides of the fold, also towards the top and bottom of the gore, pin along the edge, and round the gore. Use No. 40 basting-cotton, with a No. 5 or 6 needle. Begin to baste [for basting see Stitches and also Bodice] at the left-hand side of the waist, smoothing it as you go along, taking care not to stretch the bias side of the gore. Baste lining and material together with a stitch ¾ in. in length—with the needle straight from right to left—all round the gore, 1½ in. from the wheel-mark.

For the side gore, pin the centre of this to the centre wheel-mark of lining, and all round the edges, carefully smoothing before pinning; then baste down the centre and all round in the same way as for the front. Proceed with the back gore in the same way as the side gore.

Tacking the Gores Together. Place the side gore on the table, with the straight, or selvedge edge towards the worker and the crossway edge away. Now place the bias edge of the front gore to the straight edge of side gore, according to the marks or notches, taking care not to stretch the crossway edge, nor to lift it from the table when tacking. *Pin the material in the wheel-marks at the waist at top and bottom edge, also midway and several times between.*

Tack ½ in. only *in from the pins, making stitches* ½ in. in length, leaving the lining loose; then take out the pins and turn the lining back to the wheel-mark all along the gore. The left-side gore should only be tacked as far as the placket opening.

Tack the other gores to their corresponding edges in the same way, remembering that the selvedge edges will go to the bias ones, except of course, at centre-back, where the two crossway edges come together.

Stitching the Seams. The inside of the skirt should now present the appearance in diagram [57], where all but the back seam are tacked ready for machine-stitching, this being left open for the sake of clearness.

When machining the seams, keep the work well up to the needle; this is especially necessary if the material be at all loose, as a puckered, stretched, or drawn effect will be the result if the machine be allowed to drag the work. No. 60 cotton should be used for stitching the seams, but silk is preferable, and, if the latter, use either 36 or 40. Stitch up left side of front gore only as far as placket-opening.

Pressing the Seams. When all the seams are machined, remove the tacking-threads, also the white cotton tackings, from the seams, but be careful not to remove those of placket opening.

Before pressing, cut off the edges of the seams to about ½ in. Do not use water or a damp cloth, unless experiments have previously been made on a piece of the material to see whether it will stand this, as some stuffs will quite change colour if either be employed. Open the seams and with the aid of a covered roller and a *warm* iron, proceed to press them gently. It should be remembered that in dressmaking the word "pressing" is used in its literal sense; the iron should neither be pushed nor rubbed along, as in laundry work, but should be used with a firm, gentle pressure.

When the seams are well pressed, tack the straight edge of the lining ½ in. away from the seam of the skirt—the wheel-marks on the lining and material must now meet—then turn down the bias side ½ in. beyond the wheel-marks (to make up for losing in making), and tack over the straight edge. Note the *crossway*, or bias, edges of gores are felled over the straight ones. Now fell the turned-over crossway edge with a fine needle and No. 60 cotton. [58]

To prevent the waist getting stretched whilst the seams are being felled down, it is advisable to tack a piece of straight lining to the waist-line. Proceed with the back and side gores in the same manner, remembering that the other side of the skirt is tacked from top to bottom.

To be continued

NATURAL & ARTIFICIAL STONES

Including Granites, Slates, Sandstones, Marbles, Limestones, etc., the Manufacture of Artificial Stone, and the Preservation of Stone

By Professor HENRY ADAMS

ENGLAND is fortunately constituted for the study of geology. The various strata in their natural position, in horizontal layers one above the other, would occupy many miles, and the lower ones would be practically inaccessible. But in England they are, speaking generally, tilted up on the western side and down on the eastern side, all lying at an angle, so that on the east coast only recent alluvial deposits are found, but in travelling towards the west, the outcrop of the various strata is passed over until the igneous rocks are reached on the west coast.

Architecture Dependent on Geology. The architecture of a country naturally follows that form most suitable to the prevalent building material, so that where forests abound timber dwellings are the rule—as in Norway at the present time, and in England during its early history. Upon the disappearance of forests, recourse has to be had to the materials in the soil. Hence towards the east coast, where clay abounds, brick buildings are the rule; and towards the west, where stone is abundant, stone dwellings are more common.

The London Basin. In the neighbourhood of London there is a peculiar dip in the strata, taken across the bed of the Thames, forming what is called the London Basin [47]. A study of this will show how rocks and minerals that have been deposited at different periods may, in certain places, be seen and examined on the surface. It also shows why artesian wells sunk through the impervious London clay provide a large supply of water, it having travelled through the greensand from considerable distances.

Building Stones. Building stones may be classed as (*a*) hardstones, such as granite and several kinds of sandstones; and (*b*) freestones, such as Portland oolite, Bath stone, Caen stone, etc. They may also be divided into (*a*) siliceous stones, in which silica is the prominent constituent, such as Granite, Bramley Fall, and Craigleith; (*b*) argillaceous stones, in which alumina is the chief constituent, such as clay slate; (*c*) calcareous stones, in which carbonate of lime predominates, such as Kentish Rag, Portland, Bath, Caen, etc. Sandstones have the greatest fire-resisting ability; limestones decompose under heat, and clay, slate, and similar stones crack when heated.

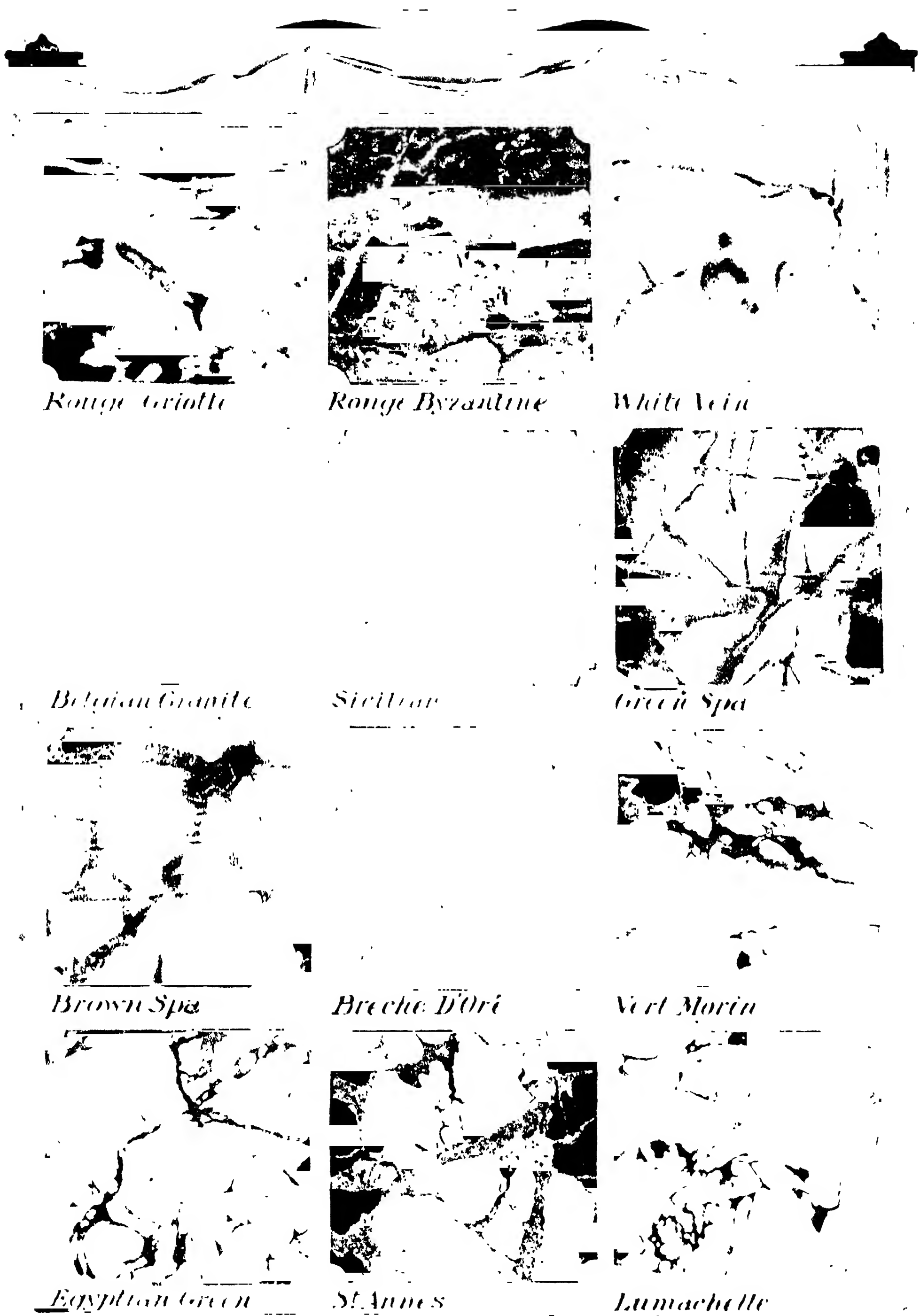
Detecting the Natural Bed. Some stones, particularly when of a laminated variety, show the natural bed at a glance, two of the faces being comparatively flat and smooth, and the others more or less in projecting portions. In other samples, stratification of coloured or crystalline particles may be observed, and when the stone contains shells the position in which they are bedded may indicate the natural bed, as they would originally be deposited horizontally. Sometimes wetting a stone helps to show up the difference in the faces and make the stratification more apparent. If the water be applied gradually, the direction in which the moisture spreads most rapidly indicates the natural bed. Under a magnifying-glass the particles composing the stone may be observed flattened in the direction of the pressure, thus showing the beds. When it cannot be detected by the eye, the mason can often tell by the feel of the grain in working it.

In considering the principal stones used in building, it will be desirable to begin with the oldest group.

Basalt. Basalt is the general name given to those igneous rocks of volcanic origin which by eruptive agencies have been forced as lava through granite and the superincumbent strata to all levels at various times. Basalts are nearly homogeneous, the component materials being finely divided and equally distributed throughout the mass, while granites consist of crystals of such size as to render the composition clearly evident on inspection. True basalt is found all over the county of Antrim in Ireland, in the Hebrides, and the North and Midland counties of England. It is of a dark green, or nearly black, colour, and so difficult to quarry and work that it is only used for road metal, paving setts, and pitchers, and the manufacture of artificial stone. It is composed of lime-felspar, augite (silicate of magnesia), olivine, and titanoferrite; when the felspar predominates, the colour is rather lighter. It generally occurs in dykes or sheets, penetrating other rocks, or lying between them or upon the surface, sometimes stratified, and at other times columnar, with six or eight sides, as in the Isle of Staffa or the Giants' Causeway. Basalt lava blocks, either rock-faced, or with drafted margins, form good plinths for heavy buildings.

Trap Rocks. Trap rocks consist of a mixture of felspar and hornblende, varying from a dense mass without apparent grain to a granular crystalline structure. The names of the varieties depend upon the district from which they come. The colours vary from greenish-grey to black. When stratified, this stone may be easily converted to paving setts, but is not suitable for use as a building stone, owing to its decomposition on exposure to the weather.

Greenstone. Greenstone is distinguished from true basalt by its containing hornblende; for example, that found at Penmaenmawr in



MARBLES OF COMMERCE, SHOWING VEINING AND COLOURING

North Wales, and at Rowley Regis in Staffordshire, known as Rowley Rag. The Penmaenmawr stone is easily split for paving setts by cutting a fine line with an axe in the direction required, and then tapping smartly with a hammer.

Whinstone. Whinstone is similar material found in various parts of Scotland. It is used as road metal.

Serpentine. Serpentine is a hydrated silicate of magnesia mixed with carbonate of lime, steatite or soap-stone, and diallage, which is a foliated variety of hornblende and dolomite. It is found in all shades of green and red, and takes its name from the mottled streaks and patches in which the components are arranged. It occurs in Galway as Connemara marble; in the Shetland Isles and North of Scotland, Anglesea, and Cornwall. It is compact in texture, but soft and easily worked, takes a fine polish, and is used for interior decorations, as it does not weather well for outdoor use in towns. The red varieties weather better than the green. They are quarried in blocks two to three feet long.

Porphyry. Porphyry is a stone of varied colours, consisting of a fine matrix with larger crystals interspersed. Felstone, or felsitic porphyry, has a base of quartz and orthoclase, known as felsite, with independent crystals of felspar. Quartziferous porphyry has a base of a granular crystalline compound of quartz and felspar, with independent crystals of quartz and felspar. It is used chiefly for road metal and paving setts, but the fawn-coloured sorts are sometimes used as building stones, although they cannot be obtained in very large blocks.

Porphyritic Granite. Porphyritic granite from Penzance and Land's End has large crystals of felspar, known as horses' teeth, and has a yellowish tint. *Shap Fell* is a porphyritic granite from Westmorland, and is of a pink, or reddish-brown colour. It takes a fine polish, and is largely used for decorative work, of which London examples are the columns at St. Pancras Station and the posts enclosing the western area of St. Paul's Cathedral.

Granite. Granite is the general term for granite and syenite and for stones of intermediate composition. It is an igneous rock of granular crystalline structure, consisting of 50 to 60 per cent. of quartz in crystals, 30 to 40 per cent. of felspar in amorphous lumps, and about 10 per cent. of mica in small detached glittering particles. The felspar is very irregular in size, and its colour gives the tone to the mass. The durability of granite depends principally upon the proportion of quartz it contains, on the regular distribution of the felspar, on the smallness of the mica grains, and upon the absence of iron in any form. The mica is the most liable to decay, but the felspar is sometimes in a state of incipient decomposition into kaolin, or porcelain clay. Potash felspar is more liable to decay than lime-and-soda felspar. There is very little waste in a granite quarry, as the larger pieces are used as building blocks, the smaller for road metal, and the chippings for the manufacture of artificial stone.

Aberdeen Granite. This granite is considered one of the best. It is a clear grey, very durable, and takes a high polish. It is extensively used for building purposes in the neighbourhood of the quarries, also for bridges and dock work. In London it is used for polished columns, pilasters, plinths, and other architectural features. It is better to have it dressed at the quarry, as it is easier to work before the quarry sap has dried out. The local men, from their experience, can also usually work it with greater facility; and as most granite quarries have machinery on the spot, those portions which can be so worked can with advantage be dressed at the quarry. The saving of freight in the reduced weight is also a consideration.

Peterhead Granite. This is a well-known variety, of a good red colour, taking a fine polish. It is largely used for constructional and decorative purposes. The pillars of the Carlton Club, London, are of Peterhead granite.

Guernsey Granite. Guernsey granite is very hard, and tends to become slippery when used for paving setts and pitchers, but is very durable. It has a close grain and bluish colour, and is generally heavier than Scotch granite.

Irish Granites. Irish granites have various shades of grey, as a rule, but that from Galway has a reddish tint, and Newry furnishes a granite of greenish colour which is more correctly a syenite.

Norway Granite. This variety, generally grey, but obtainable in other colours, is very largely used for kerbstones, for which it is preferred, as it may be obtained in long lengths.

Syenitic Granite. This granite has the addition of hornblende to the other minerals in ordinary granite. De Lank granite from Cornwall is one of the best known, and is highly appreciated from its density and light-grey colour. It is hard, compact, and durable, and was used in several works at Portland, Milford, and Devonport, as well as for Eddystone and Beachy Head lighthouses, and in Blackfriars Bridge.

Syenite. Syenite is similar in general appearance to granite, but consists of crystals of quartz, felspar, and hornblende, the latter taking the place of the mica in ordinary granite. The name is derived from Syene, in Upper Egypt, but it is also found in Leicestershire, Merionethshire, and the Channel Islands. It is generally of a dark blackish-green colour owing to the hornblende, and containing some pink, grey, or pinkish-brown crystals of felspar, according to the locality from which it is derived. It is on the whole tougher, harder, more compact, and of finer grain than ordinary granite, and of a darker colour. It is the most durable of the granite class, and will take a fine polish, but is used principally for paving setts and road metal. When the expense is not prohibitive, it may be used for exterior decoration.

Leicestershire Granite. This is a true syenite, but the colour is variable, that known as Charnwood being dark-green, Clift Hill dark-green and pink, while others are blue and pinkish-brown.

Elvan. Elvan is a fine-grained crystalline stone, composed of quartz and felspar, found in Cornwall and Devonshire; like a granite, but without mica.

Gneiss. Gneiss belongs to the metamorphic group, composed of quartz, felspar, and mica. The latter constituent occurs in layers, giving an appearance of stratification, and enabling the stone to be easily split. It is used as a building material in the bodies of walls, and also for flagging.

Mica Schist, or Mica Slate. This stone is composed of mica and quartz in thin layers, of a silvery grey, glistening colour. It is used for flagging.

Hornblendic Schist, or Hornblende Slate. This consists principally of hornblende, with a little felspar and quartz. It is tougher than mica slate, runs thicker, and is superior for flagging.

Slate. Slate is a stone formed of compressed clay, derived from the decomposition of felspar in the granite rocks washed down into ancient sea-beds, and there subjected to great pressure and heat, and the cleavage planes developed afterwards by lateral compression due to the shrinkage of the earth's crust. It is, therefore, originally an aqueous or sedimentary rock, but classed as metamorphic owing to the changes wrought in its constitution by igneous action.

The action is supposed to have been somewhat as follows: The original grains, more or less rounded, as shown in **48**, were compressed by superincumbent deposits into laminated beds [**49**], as in ordinary stratification, and then, by the great horizontal pressure due to the shrinkage of the earth's crust, the layers were forced to take a more or less vertical position [**50**]. This resulted in the original beds becoming convoluted, as shown by the wavy lines in **51**, and in cleavage planes being created, as shown by the straight inclined lines in the same figure. The upper surface being denuded by the action of the weather, glaciers, etc., does not often follow the line of the stratification.

Slates are found chiefly in North Wales, but also in Cornwall, Lancashire, and Westmorland. The blocks are sawn to various lengths, according to the size of slate required, separated into pillars [**52**], and then split along the cleavage planes to an average of $\frac{3}{16}$ in. thick. The most usual sizes are Duchesses, 24 in. by 12 in.; Countesses, 20 in. by 10 in.; Ladies, 16 in. by 10 in.; and Doubles, 13 in. by 10 in. Blue slates are obtained from Bangor, Cefn, East Cornwall, Launceston, and elsewhere. Purple slates from Carnarvon and Penrhyn; green from Elterwater, Tilberthwaite, Kirkstone, &c.; grey from Yeolmbridge and Garrybeg; red from Dinorwic. Although chiefly used for roof coverings, owing to their comparative lightness and durability when exposed to the weather, larger slabs are used for chimney-pieces, ..., shelves, steps, tanks, paving, etc., and for many other purposes in the neighbourhood of the quarries. A good slate should have a clear ring when struck with the knuckles, should be free from any earthy smell when wetted, and when stood to half its depth in water should show no perceptible rise of moisture. The conversion of a block from the quarry into roofing slates is shown in **52**.

American Slates. American slates of various colours have been introduced, but they only have one quality to recommend them—viz., cheapness in first cost.

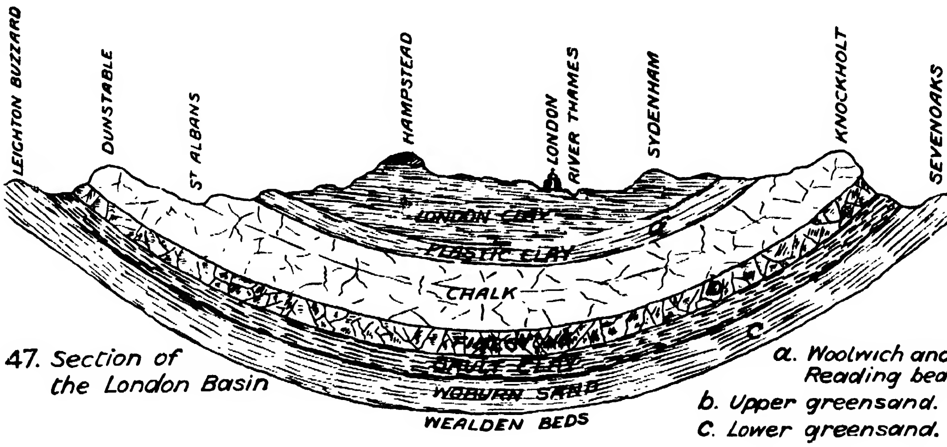
Westmorland Slates. Westmorland slates are thicker and coarser than Welsh slates. They are not made to any special size, and are termed *ton* slates, being sold by weight instead of numbers. They are sorted out into sizes on the job, the largest being fixed at the eaves, and the courses diminished in width as the ridge is approached. They are sometimes laid like glass in a conservatory roof, with a simple lap at the ends, butting at the sides against a fillet down the centre of the rafters, and the joint covered with a twice splayed wood fillet.

Enamelled Slate. Enamelled slate is used for lavatory tops, table tops, and chimney-pieces. Cornish slate makes the best slabs, but inferior slate is generally used for enamelling. The slabs are planed and rubbed, coloured black, and placed in racks in a large oven heated to 300° F. When removed, they are coloured to imitate various marbles, and again heated, and finally polished with rottenstone.

Slatestones, or Tilestones. These are not true slates, although called slates locally. A true slate does not split along its bedding planes, but along cleavage planes, more or less at right angles to the bedding planes, while the tilestones are sandstones or limestones that split easily along their bedding planes, and thus form slabs that may be used for roofing purposes. The best known are perhaps the Colyweston slates from Stamford, in Rutlandshire, consisting of a dark-grey limestone. The blocks are split into slabs by having water thrown on them in the winter, when alternate freezing and thawing cause the splitting.

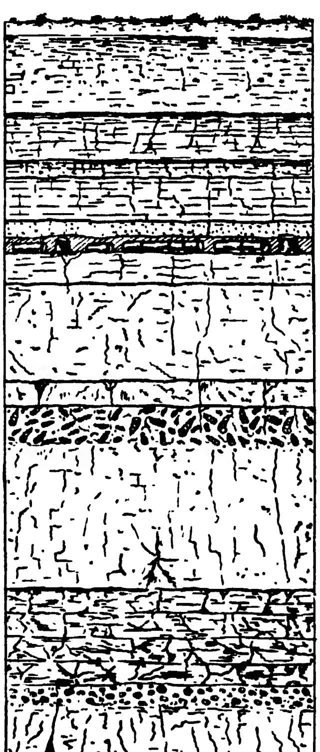
Sandstones. In sandstones the grains of quartz or silica forming the mass of the stone are indestructible, but the cementing material may be very liable to decay, as happens in the case of carbonate of lime. A dull, earthy appearance in sandstone indicates a poor quality. When the cementing material is siliceous the stone is most durable. Sandstones may be classed, according to their physical character, as liver-rock, flagstones, tilestones, and grits; or according to their composition, as micaceous, calcareous, felspathic, and metamorphic.

Shamrock Stone. This stone, which comes from Liscannor in Ireland, is a blue-grey millstone grit of two kinds, both very hard and durable. That from the top bed is used for

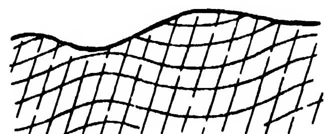


47. Section of the London Basin

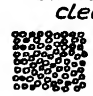
a. Woolwich and Reading beds
b. Upper greensand.
c. Lower greensand.



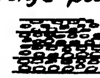
53. Section of Portland stone quarry



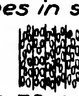
51. Stratification and cleavage planes in slate.



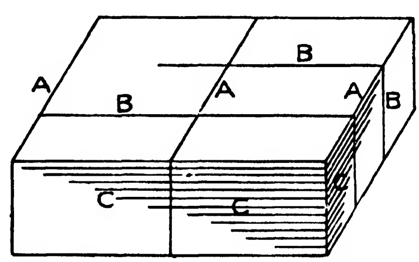
48. Original grains in slate.



49. Stratified position of grains.



50. Grains compressed vertically.



52. Conversion of slate block.
A. Saw cuts.
B. Pillars
C. Cleavage planes

54. Portland screw fossil

kerbs, setts, pitching, and building blocks for engineering purposes. That from the lower bed is slightly laminated, and can be split very truly for pavings, landings, flags, and steps. It is very durable, as it is free from carbonates.

Bristol Pennant, or Blue Pennant. This is a hard sandstone of a blue colour, very good for municipal work, such as pavings, kerbs, channelling, and pitching; also for steps, landings, caps, copings, and girder-beds.

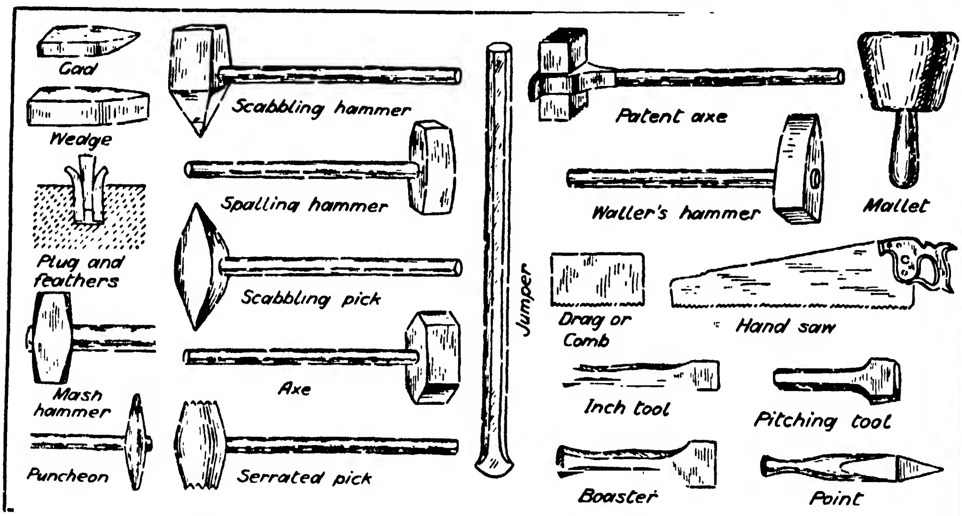
Craigleith and Hailes Stone. This is considered to be the most durable sandstone, containing only 1·1 per cent. of carbonate of lime, and 98·3 per cent. of silica. It is a silvery white or pale-grey colour, with crystalline fracture, and largely used for all purposes where strong, good weathering stone is required. It is very free from defects.

Darley Dale. Darley Dale is a white sandstone with very little carbonate of lime, but containing 1·3 per cent. of oxide of iron and in three distinct beds, the first two series being of a grey colour, and the bottom bed of a bluish tint. The stone is well adapted for building or for heavy engineering work, such as docks and bridges. It was used in the construction of Cardiff, Swansea, Gloucester, and other docks.

Closeburn Red Freestone. This variety, quarried in Dumfriesshire, has very good weathering qualities. Examined under a microscope, it is seen to consist of angular fragments of quartz, with a cementing matrix of a ferruginous silico-argillaceous character, by which they are firmly interlocked. It has a good red colour, which does not fade.

Robin Hood. Robin Hood is a greenish-grey sandstone, quarried near Wakefield, in Yorkshire. It is very durable, and is largely used for landings, staircases, and sawn slabs.

Park Spring. This is a light ferruginous brown sandstone from Farnley, near Leeds, in Yorkshire, occurring in irregular beds. Much of



TOOLS USED IN QUARRYING AND WORKING STONE

alumina. It is compact and very hard, and is extensively used for general building purposes, as it weathers well.

Abercarne. Abercarne is a blue Welsh sandstone, very similar to blue Pennant.

Bramley Fall. This is the most noted of the Yorkshire sandstones, of homogeneous structure. The original is all worked out, but good stone is still obtained from the same neighbourhood, although in thinner beds. It is much subject to iron stains. The lamination of York stone, as used for flags, is due to plates of mica running in one plane.

Scotgate Ash. This is a light-brown York stone, chiefly used for steps, landings, copings, and sinks. One of the beds is called ragstone, which is recommended for heavy engine bases and foundations.

Forest of Dean Stone. This stone, found in the coal measures of Gloucestershire, is the stone known as Park Spring comes from other quarries.

Beer. Beer is classed both as a sandstone and limestone, owing to its constituents. It is a light-brown Devonshire stone, soft when first quarried, but becoming harder by exposure.

Limestones. Limestones, when compact and crystalline, are almost free from defects. As a class, they are rather soft and absorbent, and liable to sand cracks. They vary very much in texture, from the pure crystalline structure of marble to the roe-like structure of Ketton and Bath stone, the shelly structure of Ancaster, Purbeck, and Portland, and the homogeneous structure of Kentish Rag. They are classified, according to their physical properties, as compact limestones, granular limestones, shelly limestones, and magnesian limestones.

Keinton Stone. Keinton stone is a blue lias limestone used for floors, landings, steps,

hearths, pavements, kerbs, and channeling, and is both cheap and lasting. It is also used in the manufacture of lias lime.

Kentish Rag. This is a very homogeneous stone of a blueish colour, extremely tough, so that it is not readily dressed with chisels. It is commonly used as a facing stone for churches in the style known as "polygonal ragwork." It is liable to patches of hassock, which is a soft, porous stone like compact sand. It is also liable to pockets of iron pyrites, which, if exposed to the atmosphere, oxidise and cause rust stains. Of the various beds, *Pelsea* yields large hard blocks 12 in. thick, but difficult to quarry. *Whiteland Bridge* produces blocks 12 ft. long of any width, and is very free in working. *Horsebridge* yields blocks of good stone 15 ft. long and 16 in. thick. The other beds yield only small stones fit for rubble, kerbing, and pitching.

Marbles. *Ashford* is a black Derbyshire marble used for chimney-pieces. *Berry Pomeroy* is a red and white Devonshire marble. *Carrara* is an Italian marble of a pure white, close-grained and uniform, used for statuary, headstones, and chimney-pieces. *Rouge Royal* is a French marble, red and brown veined, used for chimney-pieces and table tops. *Tullamore* is a grey Irish marble used for chimney-pieces and internal decorations. *Hopton Wood* is a fine-grained, compact stone of a warm light-grey colour. It weathers well, and is largely used for steps, paving, etc.; it will also take a good polish, and may be classed as a marble. *Purbeck Marble*, from the upper oölite beds, is of a grey colour, and is capable of taking a polish, although cavities frequently occur which have to be filled with wax. It was much used for the slender shafts in the interior of old churches, as in the Temple Church, London, and is still largely used for internal church work. The veining and colouring of the best figured marbles are shown in the frontispiece.

Oölites. This name is given to those limestones which show a distinct structure like the hard-roe of a fish. As a rule, they are bad weathering stones. *Portland Stone* is obtained from the upper parts of the oolitic series, and consists of four distinct varieties of building stone, known as *True Roach*, *Whitbed*, *Curf*, and *Basebed*, all of which are of a whitish-brown colour, weathering to a bluish tint, but of widely different structure. The section of a Portland-stone quarry is shown in **53**. The upper portion being excavated, the top cap and roach are blasted, and the whitbed and basebed are quarried by wedges and levers. True roach may be distinguished from the other varieties by the peculiar fossil it contains, known as the "Portland screw" [**54**]. This stone is tough, strong, weathers well, and is particularly good for resisting the action of water, for which reason it has been largely used for breakwaters, dock and sea walls, etc. Whitbed is, perhaps, the most valuable building stone in the Portland series. It weathers admirably, is easily dressed to a smooth surface, and will take a fine arris, and is therefore suitable for the best class of ashlar work. Curf, or bastard roach, resembles true roach very closely, but is inferior in almost every respect. It is largely used in the locality of the quarry, and is suitable for foundations and backing walls. Basebed is almost identical with whitbed in appearance, but is softer, and not such a good weathering stone; it is well adapted for the finest class of internal work and carving.

Ancaster. Ancaster is a cream-coloured compact, and fine-grained oölite, but is found both white and brown. The white is a hard, close-grained stone, with small hard shells apparent. It works very much like Bath stone, and weathers well. A number of the Lincolnshire churches are built of this stone, and it is used locally for building work generally, but in London its principal use is for door and window dressings.

Bath Stone. Bath stone is the name applied to the stone found in the Great, or Bath oölitic formation. It is obtained from many different quarries, of which Box Ground, Corsham, and Coombe Down are among the best. Box Ground is the best weathering stone, and is largely used for dressings, carved, and moulded work. Corsham, when fine-grained, is used for sculpture and mouldings, but that known as "corngrit" Corsham is very hard, and especially suitable for engine-beds, landings, etc.

Caen. Caen is a fine oölite found in Normandy, and largely imported into England. It weathers badly, and is unsuitable for external work, but it is well adapted for internal carving, and is much used for internal decorative work.

Chilmark. This, also known as *Wardour* stone, and in London as *Tisbury*, is a light greenish-grey to yellowish-brown oölite. It is largely used for building work generally, but is specially suitable for steps, pavings, and road metal, also for heavy engineering work, and any position exposed to wet and hard wear; the Pinney beds for door and window dressings, moulded string courses, cornices, etc.; Trough bed for steps, and Wardour Garden bed for internal moulded arches where great strength is required.

Doulting Stone. This is a shelly, granular oölite, the colour of which varies from cream to a light brown. It is very uniform in texture, durable, free working, and is largely used for general building purposes.

Edithweston Freestone. This stone is similar to Ketton stone, and from an adjacent quarry. It is of a fine, even texture and good colour, easily worked with a fine arris, hardens on exposure to the weather, and withstands London smoke.

Ham Hill. Ham Hill is a light yellowish-brown stone, bright when first quarried, but the colour soon tones down. The beds vary considerably in quality, but the best is very durable and strong, weathers well, and is used for facings and dressings.

Ketton. Ketton is a very durable oölitic stone, of a creamy-pink colour, called roestone by masons. It is suitable for dressings, plinths, stairs, etc., and was used in the recent parts of Peterborough and Ely Cathedrals, and at St. Pancras Station. The ragstone beds are white, cemented with highly crystallised carbonate of lime.

Painswick. Painswick is a cream-coloured limestone from the upper oölite, of very uniform grain. It is suitable for internal staircases, and was used in the construction of the Houses of Parliament.

Seacombe. Seacombe is a light-grey to light-brown oölite from the Purbeck beds. The whitbed from this quarry is a very good stone, of even colour, strong, and very durable under wear, so that it is an admirable stone for stairs. It is also used for kerbing and for dock walls.

Dolomites. Dolomites are those magnesian limestones which have an atom of carbonate of lime for each atom of carbonate of magnesia, giving a result equivalent to an alloy in metals. *Bolsover Moor* is a light yellowish-brown magnesian limestone. This stone was at first selected for the Houses of Parliament, but the quantity required was more than the quarry was capable of supplying. It is a durable building stone, and is also largely used for paving. *Roche Abbey* is a whitish-cream stone which weathers dark, and in lines according to the beds. It is, however, used for general building purposes. *Mansfield (yellow)* is generally classed as a limestone, as half its bulk consists of carbonate of lime, but some Mansfield contains a much larger quantity, and is on that account not such a good weathering stone. *Mansfield (red)* is classed as a siliceous dolomite; it is a ruddy brown, and loses some of its colour on exposure, and is a fairly good weathering stone. *Mansfield (white)* is a similar stone, of a greyish-white colour, used for steps and landings. Both these varieties, red and white, are sometimes classed as sandstones.

Artificial Stone. Artificial stone is a manufactured article intended to be used as a substitute for natural stone. There are many different kinds, passing under distinctive names, but they may be classed under three groups: Ordinary, or simple cement concretes; hardened cement concretes; and chemical stones. Simple concretes are mostly composed of granite aggregate, with Portland cement as the matrix, and they have the advantage of either being laid *in situ* or cast in moulds to the true form required. Some of the best known simple concretes made are: Stuart's Granolithic, Ward's Synthetic Stone, Globe Granite, and Basaltine Stone, the aggregate of the last-mentioned differing from the others in that it consists of basalt chippings, while trass is mixed with the cement. Of those concretes which are subjected to the hardening processes, Victoria Stone, Imperial Stone, Indurated Stone, and Empire Stone, are perhaps the best known.

Victoria Stone. Victoria stone consists of an aggregate of crushed Leicestershire granite After the aggregate has been well washed, three parts are thoroughly mixed with one of Portland cement in a dry state, and the water then carefully added, to prevent washing out the fine cement. As soon as mixed, and before any setting takes place, the mixture is put into the moulds, care being taken to fill up all the corners in order to obtain fine arrises. When filled, the moulds are allowed to remain until the concrete has sufficiently set, the fastenings are then released, and the moulds, which are made in pieces, can then be readily detached. The slabs are next placed side by side in a tank containing sufficient silicate of soda solution to cover them, and they are left there for about 14 days. They are then stacked in the storeyard to season, and are used in the order of their age. Victoria stone is mostly used for paving slabs, but is also cast for steps, balustrades, etc.

Imperial Stone. Imperial stone is very similar to Victoria stone, the chief differences being that the slabs are subjected to steam during setting, which enables the moulds to be removed in one day; they are placed in the silicate tanks for only three days, and are stacked for six months before use. Imperial stone pipes are made in a similar manner to the slabs, the only difference being that crushed flint is used for the aggregate in the place of granite.

Ford's Silicate of Limestone. This is the best known of the chemical stones. It is made of fine sand (silica) and chalk lime in the proportions of about 94 per cent. silica to about 6 per cent. lime, mixed and rammed dry into a perforated steel box mould. The air is then extracted from the box, and boiling water forced in under pressure, which slakes the lime and then escapes through the holes. Afterwards, to ensure the thorough slaking of the lime and its combination with the silica, superheated steam is forced in under a pressure of 120 lb. per square inch. The resulting stone resembles a sandstone, and the entire operation of manufacture only takes about eight hours. *Chance's Artificial Stone* is made by melting Rowley Rag basalt and casting it in moulds to the shape required. *Rust's Vitrified Marble* consists of a mixture of glass and sand fused together and run into moulds.

Preservation of Stone. *Fluate* is a solution of fluate of magnesia, obtained by dissolving crystals in soft water applied to Bath and other soft limestones, converting them into a substance identical with fluor spar, which is insoluble, and therefore practically imperishable. For non-calcareous stones, a solution of lime is first used upon which the fluate can act.

Szerelmey's Stone Liquid. This is a soluble glass, which is painted on the surface, and is slowly absorbed, penetrating the surface and forming a waterproof layer impervious to moisture. It is transparent, but can be coloured to any shade desired.

Painting the stone is sometimes done, but is not desirable, as it changes the colour and hides the natural grain, giving an artificial appearance. It also imprisons the moisture in the stone, and increases the risk of fracture by frost. Paints do not adhere well to stone, and, becoming oxidised by the action of the air, have to be periodically renewed

To be continued

A SYNOPSIS OF THE GEOLOGY OF THE CHIEF KINDS OF STONE

To understand the formation and relative geological position of the various stones, it is necessary to present a synopsis of the whole. Different writers adopt various classifications. The principal divisions are shown in this table.

Epoch.			System.	Group.	Character.	Contents.
Cainozoic	Tertiary	Aqueous or Sedimentary	Post Tertiary	In progress and recent	Alluvial deposits. Peat mosses. Coral reefs. Raised beaches.	Plants and animals of existing species.
			Tertiary.	Pleistocene	Fossiliferous clays and sands. Boulder or drift formation.	Plants and animals extinct but not widely different. Birds. Mammalia of existing orders. Foraminifera. Megatherium.
				Pliocene	Mammaliferous clays.	
				Meiocene	Red crag. Coralline crag.	
				Eocene	Fluvio-marine beds I. of W. Bagshot sands. London clay. Bognor beds. Plastic clay.	
Mesozoic	Secondary		Cretaceous	Chalk	Upper soft white. Lower hard, dark, few flints. Chalk marl. Tottenhoe stone.	Plants and animals, chiefly marine; now extinct. Ammonites. Belemnites. Teeth. Sponges. Corals. Coprolites. Iguanodon.
				Greensand	Upper soft or hard. Gault. Lower various. Kentish Rag.	
			Oölitic	Wealden	Weald clay. Hastings sands. Purbeck beds. Limestones.	Plants and animals of families now extinct. Hugereptilia. Palms. Coniferæ. Trigonia. Ammonites. Belemnites. Nautilus. Icthyosaurus. Plesiosaurus.
				Oolite	Upper—Portland stone. Kimmeridge clay. Middle—Coral rag. Oxford clay. Lower—Cornbrash. Fuller's earth.	
				Lias	Upper—Bituminous and alum shale. Lower—Dark limestones. Ironstones. Jet. Lignite.	
			New Red Sandstone	Trias	Upper—Variegated marls. Gypsum. Rock-salt. Variegated sandstones. Corsehill, Grimshill, and Runcorn stones.	Plants and animals not abundant. Families extinct. Palms. Pines. Small bony fish.
Palæozoic			Carboniferous	Permian	Middle—Laminated limestone. Gypseous marl. Magnesian limestone. Marl slates. Lower—Red sandstone on coal.	
				Coal measures	Coal.	Plants and animals abundant. Excess of tropical vegetation. Tree ferns. Equisetums. Marine shells and zoophytes. Encrinites. Terebratula.
				Millstone grit	Fireclay. Ironstone.	
				Mountain limestone	Carboniferous limestone.	
				Lower coal measures	Carboniferous slates.	
			Old Red Sandstone	Yellow sandstones	Fine-grained stone. Scotch pebbles.	Plants few and imperfect. Fishes abundant. Other animals rare. Ganoid, placoid and ctenoid fish. Small reptiles.
				Red conglomerates	Coarse red conglomerate. Red sandstone.	
				Grey fissile sandstones	Grey micaceous and flaggy sandstones.	
			Silurian	Upper Silurian	Ludlow tilestones. Wenlock limestones.	Trilobites. Graptolites. Serpulites. Encrinites. Terebratula. Orthoceris.
				Lower Silurian	Llandeilo rock. Shelly limestone. Freestones.	Eozöon.
Azoic	Transition		Metamorphic	Clay Slate	Roofing slates and slabs.	No Fossils.
				Gneiss and Mica Schist	All hard crystalline rocks.	No Fossils.
	Primary	Igneous	Igneous	Granites and Basalts	Granite. Syenite. Whinstone. Greenstone.	No Fossils.

Group 19
LITERATURE
4
Continued from page 328

POETRY OF THE ELIZABETHAN AGE

I. The Lyric Poets. Being a Short Study of Sidney and Spenser, and a Review of the Lesser Writers to the End of the Sixteenth Century

By J. A. HAMMERTON

WHEN we turn our attention to the poetry of the Elizabethan age, it is as though we were looking with unskilled eyes upon a starry heaven, so bewildering and so brilliant are the names that glitter in the literary firmament of that wonderful age—Shakespeare, the " bright particular star." With the awakening of the English nation to a new and grander perception of national patriotism, the dusky clouds of mediævalism had been suddenly dispersed by the bright sun of a new day.

It is indeed hard to resist the temptation which besets every writer on the Elizabethans to let rhetoric displace criticism, to decorate one's chronicle with " purple patches." But here the necessity to condense is so imperative that we must content ourselves by dealing very briefly with most of the poets who now call for attention ; and, as in almost every case it will be necessary for the reader to make direct acquaintance with their work, there is the less need for biographical or critical detail. This may be thought an unprecedented method to adopt, but we are prepared to defend it on the ground that in a practical guide to English Literature it is more necessary to deal at some length with those writers who, while sufficiently important from the historical point of view, are not urged upon the reader for his personal study, than with those whose works must be read.

The New Era. Of course, there was nothing miraculous in the outburst of poetry which heralded and accompanied the Elizabethan age ; the dawn of the new era did not come so suddenly as the hyperbole of the impassioned historian would suggest. If from the time of Chaucer the genius and imagination of the country had languished, scholarship, at least, had ripened ; and, as we have heard, the mediæval age did not pass away without leaving a legacy to the age that followed, since the English language had assumed, in the poetry of Wyatt and Surrey, a greater perfection of form than it had hitherto possessed, and it was now to be used by writers imbued with loftier idealism than that of the age of chivalry and old romance. But for some little time yet we would naturally expect to find the older notions of life still actuating writers who, chronologically, are to be reckoned Elizabethans. This is true in some measure of Spenser and his friend and patron, Sidney, both of whom were born some four years before the accession of Elizabeth.

SIR PHILIP SIDNEY

Sir Philip Sidney. Although the figure of SIR PHILIP SIDNEY (b. 1554 ; d. 1586) is one of the most familiar in literary history, it is not unreasonable to suggest that this is due as much to his remarkable qualities as a man as to his literary gifts. Indeed, we do not purpose dwelling at any length on Sidney's poetry, for he will merit more consideration when we come to the study of English prose. Wyatt and Surrey could write sonnets as good as his, but he was the first to write the prose of art. We notice, for instance, that the late Francis Turner Palgrave, an unerring judge, could find only one little love ditty of Sidney's to include in his " Golden Treasury of English Songs and Lyrics." None the less, Sidney was a poet of no mean parts, somewhat affected, it is true, but destined to live in several of his sonnets, such as that beginning, " With how sad steps, O Moon, thou climb'st the skies," and another, " Come sleep, O sleep, the certain knot of peace." But so much good poetry has been written since the days when Sidney was deemed by his admiring contemporaries one of the foremost literary men in England that readers of to-day need not fear the charge of philistinism if they are content merely to make his acquaintance in a volume of selections.

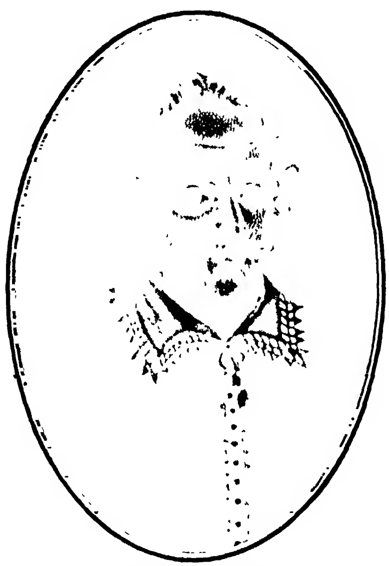
About the Sonnet. We print on the next page one of the sonnets above-mentioned to illustrate at once a good example of Elizabethan verse and the reason why it falls short of perfection. It is part of our plan, as we proceed with our studies, thus to give specimens of each new form of verse when it comes up for consideration.

"With how sad steps, O Moon, thou climb'st the skies,
How silently, and with how wan a face!
What! may it be, that even in heavenly place,
That busy Archer his sharp arrows tries?
Sure if that long-with-love-acquainted eyes
Can judge of love, thou feel'st a lover's case;
I read it in thy looks; thy languish't grace,
To me that feel the like, thy state descries.

Then, even of fellowship, O Moon, tell me,
Is constant love deem'd there but want of wit?
Are beauties there as proud as here they be?
Do they above love to be lov'd, and yet
Those lovers scorn whom that love doth possess?
Do they call virtue there ungratefulness?"

A careful reading of these verses will show that the poet has not risen superior to the exigencies of rhyme, for in the last line sense is subordinated to sound, the question being not whether virtue is there called ungratefulness, but whether ungratefulness is there called virtue. If we transpose the two words the line is intolerable, having neither rhythm nor rhyme. As it stands it has both, but the sense is obscured. The strict form of the sonnet as it was brought to perfection by the Italians — Petrarch, Tasso, and Dante—gave two rhymes only in the first eight lines or "octave" arranged as above, and two only in the concluding six lines, or "sestette," where Sidney has used three, a change of thought being expressed in the second division of the little poem. Neither Wyatt nor Surrey observed these rules strictly, and innumerable arrangements of the rhymes have been adopted, but a sonnet must never have more or less than 14 lines, and in this narrow space many a masterpiece of poetry has been composed.

Edmund Spenser. Sidney's friend, EDMUND SPENSER (b. 1552; d. 1598), was a poetical star of much greater magnitude. Indeed, Spenser is esteemed by many the finest of English poets before Shakespeare, though his great contemporary, the unhappy Christopher Marlowe, was to exercise far more influence over the greatest of all poets. Remembering the point of view we are endeavouring to maintain, it is difficult to decide how we are to regard the poetry of Spenser. As far as possible we are striving to repress mere personal inclination in dealing with each writer; but we are constrained to confess ourselves among those who have found it a tedious task to read "The Faëry Queen," the most celebrated of Spenser's poems, and consequently hesitate to urge it upon others. When Pope was only 12 years old he read it "with infinite delight," and Southey confesses to having read it thirty times over; but it is doubtful if the enthusiasm of these eminent admirers of the poet is alone sufficient to induce the ordinary reader to bear Spenser company through the six books of "The Faëry Queen." In the plan of the work we still find that characteristic of mediæval literature, a set scheme of stories told for some given purpose, as in the "Decameron" and "The Canterbury Tales." The Fairy Queen is supposed to be holding her annual feast, of 12 days' duration, and on those 12 days 12 different complaints are submitted to her. To redress the wrongs thus brought to her knowledge she commissions 12 knights, each of whom is noted for a certain virtue, and his doings are celebrated throughout a whole book. But, in addition to such heroes as the Knight of the Red Cross (Holiness), Sir Guyon (Temperance), and the lady-knight Britomartis (Chastity), there is the superlative figure of Prince Arthur, in whom all knightly virtues are combined, and who, appearing in every book, is designed as the general hero in quest of Gloriana, or Glory.


EDMUND SPENSER

The Spenser Stanza. It has been considered by good critics that the verse of "The Faëry Queen" was an ill choice on the part of Spenser, who, taking the stanza of eight decasyllabic lines, added a ninth, two syllables longer than the others, thus unduly drawing out the metrical movement and handicapping himself in the choice of rhymes, in which the English language is by no means rich. But many of our finest poets have used the same stanza with perfect effect, as in Burns's "The Cotter's Saturday Night." We give an example of the "Spenser stanza":

"A gentle knight was pricking on the plain,
Yclad in mighty arms and silver shield,
Wherein old dints of deep wounds did remain,
The cruel marks of many a bloody field;
Yet arms till that time did he never wield:
His angry steed did chide his foaming bit,
As much disdaining to the curb to yield:
Full jolly knight he seem'd, and fair did sit,
As one for knightly jousts and fierce encounters fit."

The last line is called an Alexandrine, as it is of that measure of verse first used in early French romantic poems on Alexander the Great. Pope criticised it in his well-known couplet:

" A needless Alexandrine ends the song,
That like | a wound | ed snake | drags its | slow length | along."

Spenser's Place among the Poets. But there can be no manner of doubt as to the eminent place of Spenser among the English poets (if we except such untempered praise as Dryden gave him), for he is an obvious master of epic poetry, his invention inexhaustible, the rhythm of his verse the very perfection of poetic form, his imagination so rich and sensuous that Campbell aptly called him "the Rubens of English poetry." Despite all this, and the fact that he is Milton's acknowledged master, it is true that he is not, on the whole, a poet for the general reader; and, let the critics say what they may about the critical shortcomings of Macaulay and Hume, there is more honesty in the statement of the latter than in the affected enthusiasm of many Spenserites when he writes: "The tediousness of continued allegory, and that, too, seldom striking or ingenious, has also contributed to render 'The Faery Queen' peculiarly tiresome; not to mention the too great frequency of its descriptions and the languor of its stanza. Upon the whole, Spenser maintains his place upon the shelves among our English classics; but he is seldom seen on the table." Macaulay, too, is very human when he complains that "we become sick of the cardinal virtues and deadly sins, and long for the society of plain men and women." Spenser has been called "the poet's poet," which means that to get the best from him the reader himself must be of so poetic a temperament that "the linked sweetness long drawn out" of his poetry does not cloy, but rather whets and stimulates the mental appetite. Still, Spenser is a poet with whom the ordinary reader should at least make acquaintance, as some knowledge of his writings is essential to the proper appreciation of Elizabethan literature. His first great work, "The Shepherd's Calendar," a tuneful but joyless and affected pastoral poem, with little of the warm humanity we find in Chaucer, is to be regarded as the opening pæan of that mighty chorus which we call the Elizabethan poetry.

His Life. Spenser was born in London of a poor, but honourable family, some five or six years before the accession of Elizabeth in 1558. Educated at the Merchant Taylors' School and Cambridge University, he early won the friendship of Sidney, to whom he dedicated the "Calendar," and it was through the influence of his friend that he received, in 1580, an official appointment in Ireland, where the remainder of his short life was passed, for the most part, in a state of prosperity. In 1590 the first three books of "The Faery Queen" were published, and brought him great fame. Six years elapsed before the other three and a fragment of the seventh were printed, and three years later, a fugitive from the rebel Irish who had sacked and burned Kilcolman Castle in County Cork, which for more than 10 years he had occupied under Royal favour, we hear of his death at a tavern in King's Street, Westminster—"for lacke of bread," said Ben Jonson, despite all his fame.

Raleigh and Others. Sir Walter Raleigh (b. 1552; d. 1618) is only incidentally a poet. He belonged to an age when every man of note seems to have had some literary talent, and his verse is graceful, free from the more pronounced affectations of the period, but of no extraordinary quality. More noteworthy are his prose writings.

Sir John Harrington (b. 1561; d. 1612), the translator of Ariosto, the Italian poet, need only be mentioned; none but specialists in the period will care to acquaint themselves with his work. And the same may be said of Edward Fairfax (b. about 1580; d. 1635), though all scholars who can speak with authority are agreed that his translation of Torquato Tasso's "Recovery of Jerusalem" is admirable, and much superior to Harrington's rendering of "Orlando Furioso."

Michael Drayton. A Warwickshire man and a friend of Shakespeare, who entertained him and Ben Jonson at Stratford a few weeks before his death, Michael Drayton (b. 1563; d. 1631) was a lyric and descriptive poet of very unusual qualities. He was not a great poet, though certain of his contemporaries entertained the most extravagant estimate of his merits. His chief work was conceived and carried out on a plan which made it hopeless of continued popularity. It was called "The Polyolbion," and may be described as a topographical account of England, displaying wonderful learning, but utterly mistaken in its medium, which should have been prose. It contains many quick and glowing descriptions of natural objects, but some of its passages read like catalogues of birds and beasts, thus:

" To Philomel the next, the linnet we prefer;
And by that warbling bird, the woodlark place we then,
The red-sparrow, the nope, the redbreast, and the wren.
The yellow-pate, which though she hurt the blooming tree,
Yet scarce hath any bird a finer pipe than she.
And of these chaunting fowls, the goldfinch not behind,
That hath so many sorts descending from her kind."

Our quotation is given not only to show Drayton's manner, but to illustrate at greater length a metre which we have already noted in connection with Spenser's stanza. That is the iambic hexameter, or Alexandrine, first used in English by Robert of Gloucester in the latter part of the thirteenth century, and adopted by Drayton in the "Polyolbion" for the first time in modern English. Drayton is seen to better advantage in the "Barons' Wars," a long poem, which, though uninteresting on the whole, abounds in passages of great spirit. In short,

he is a poet worthy of some attention, even from those who are not making a special study of the period.

Sonneteers and Allegorists. WILLIAM DRUMMOND (b. 1585; d. 1649), of Hawthornden, near Edinburgh, the friend of Drayton and of Ben Jonson, the latter of whom visited him in 1618–19—which occasion Drummond turned to literary profit by making his "Notes" of Jonson's conversation; a very interesting chapter of literary history—was one of the most accomplished minor poets of his age, examples of his sonnets being found in most anthologies. SAMUEL DANIEL (b. 1562; d. 1619), whom Jonson described as "a good, honest man, but no poet," wrote many beautiful sonnets greatly admired by Drummond. JOHN DONNE (b. 1573; d. 1631) was the greatest preacher of his day, and a poet of the "metaphysical" school, of which, indeed, he was the chief. His "Life" is one of Izaak Walton's masterpieces. Donne's poems do not possess any great interest for the general reader. His chief characteristic is extravagant imagery, which even in purely amatory verse is offensive, but when invoking the Most High comes little short of blasphemy. Thus, in his "Hymn to Christ," written "at the author's last going into Germany," and opening with several grotesquely inappropriate conceits, he goes on in this strain:

"I sacrifice this island unto Thee,
And all, whom I love here, and who love me;
When I have put this flood 'twixt them and me,
Put thou Thy blood betwixt my sins and Thee.
As the tree's sap doth seek the root below
In winter, in my winter now I go
Where none but Thee, th' eternal Root
Of true love, I may know."

This is surely an example of the vilest taste.

GEORGE WITHER (b. 1588; d. 1667) was the most prolific writer of the time, and his work is very unequal, so that the curious way in which it has suffered neglect and revival is not surprising. Dryden was by no means unfair when he wrote of him:

"He fagotted his notions as they fell,
And if they rhym'd and rattled, all was well."

But he will always be remembered, if only for that exquisite lyric beginning:

"Shall I, wasting in despair,
Die because a woman's fair?"

THOMAS CAMPION (b. 1540; d. 1623), poet, critic, and musician; ROBERT HERRICK (b. 1591; d. 1674)—it is curious to note, by the way, that the lyric poets were all longer lived than the dramatists of the same period—one of the sweetest singers in our language, whose "Hesperides" is a collection of unrivalled lyrics; FRANCIS QUARLES (b. 1592; d. 1644), immensely popular in his own day and after as a writer of religious poems, whose "Emblems, Divine and Moral," are still worthy of attention; and GEORGE HERBERT (b. 1593; d. 1633), like Quarles, one of the least objectionable of Dr. Donne's school of metaphysical or allegorical writers, and a better than his master, were the only other lyric poets born before the close of the sixteenth century with whose works the ordinary reader need concern himself. We have space to note the names only of Thomas Watson, Phineas and Giles Fletcher, William Browne, Sir John Davies, and Thomas Carew, "that delectable versifier," among the many other minor poets born in the sixteenth century.

We have not followed the usual plan of dividing the Elizabethan age into two periods, but have deemed it more convenient for the progress of our study to thus review at once the poets who are epic, as Spenser; narrative, as Drayton; or lyric, as Sidney; reserving the dramatic writers for separate consideration. Naturally, some of the dramatists wrote lyrical verse also—Ben Jonson's "Drink to me only with thine eyes," for example, being one of the most exquisite songs in our language—but we must regard them as essentially dramatic poets. Perhaps our arrangement is somewhat arbitrary, since there was no great distinction between the lyric poets of the second half of the sixteenth and the first half of the seventeenth centuries, and there was necessarily much overlapping of writers; but it serves at least to give us some idea of the poets of the lesser order immediately preceding, contemporary with, and following Shakespeare and the Elizabethan dramatists

Books to Read. The ordinary reader may be content to study all the poets we have mentioned in volumes of "specimens." There is no reason why he should set himself the task —for such it would be in a very real sense—of studying all their works, or, indeed, all the works of any one of them, as a very fair conception of their respective merits and their united influence on the literature of our country can be obtained by reading some of their longer poems and a selection of their minor pieces. We give below a list of books, several of which may be used for this purpose; there is abundance of such works published at low prices.

EDITIONS OF THE POETS

"The Spenser Anthology," edited by Professor Edward Arber, and published by Mr. Henry Frowde at 2s. 6d., gives an admirable selection from the chief poets between 1548 and 1591.

"The Canterbury Poets" Series (Scott, 1s. each) contains volumes of selections from Spenser, Herrick, and Herbert.

Spenser's Works in Globe Series (Macmillan, 3s. 6d.).

Drayton's "The Barons' Wars" was last published in Morley's Universal Library, at 1s.

The Lyric Poets Series (Dent, 2s. 6d. net each) contains volumes of selections from Sidney, Spenser, Herrick, and Campion.

"The Golden Treasury of English Songs and Lyrics" (Harmsworth Library, 1s. net) is indispensable to the student of poetry.

To be continued

Continued from page 416

BRACED STRUCTURES

The Warren Girder. Means of Ascertaining Stability of Walls and Dams. Crane Jibs and Roof Trusses in Practice

By JOSEPH G. HORNER

Calculations for a Warren Girder. Our next example [38—40] is a Warren girder, with 56 ft. span, subjected to loads imposed at intervals of 8 ft. on the upper boom. The angle of the diagonals is 45°, the depth of the girder is 4 ft. 6 in.

Lay out the frame diagram as in 38, making its depth 4 ft., this being the approximate depth of the frame measured between the boom centres; mark off the vertical loads, and the reactions at the supports, as shown, then letter in accordance with Bow's notation, as already explained—*i.e.*, place a letter in each space between the external loads, and also one in each internal space. Note that the end vertical members being in simple compression do not enter into the diagram; also that there is no load on the end horizontal members, the final load being carried to the ends by the members LK and XK.

Load Diagram. Construct the load diagram to as large a scale as possible [39], marking off the vertical loads AB, BC, CD, DE, EF, FG, GH, and HJ, proportionate to the tons 4, 8, 8, 8, 8, 8, 8, 4, and closing it with the reactions AK and JK. Then set off the horizontal member BL until it intersects KL. Lay down the diagonal LM till it cuts KM, and so on with each diagonal and horizontal in turn. Note that members QR and RS have no load, and are consequently termed redundant members—that is, they are not theoretically necessary to the girder-frame, but are put in for convenience of manufacture, to give mechanical support to the lower boom, and for the sake of appearance.

The loads may now be scaled off, and the various sections determined. The maximum boom load occurs in ER, QK, and SK, and scales 96 tons. The area required in the bottom, or tension boom at, say, 6 tons of stress per square inch $= \frac{96}{9} = 16$ square inches, whilst the area required in the top, or compression boom at, say, 5 tons per square inch $= \frac{96}{5} = 19{\cdot}2$ square inches. These sections may be proportioned thus:

	Net area.	Gross area.
2 angles 5 in. × 5 × ½ in. =	8·7 sq. in.	9·5 sq. in.
2 plates 14 in. × ⅜ in. =	9·3 „	10·5 „
Total.. ..	18·0 „	20·0 „

Net Area. The net area allows for rivet holes cut through the section, one ⅞ in. hole in the angle bar, and two ⅞ in. holes in the plate. A single ¾ in. plate might be used in place of the two ⅜ in. ones, but it would require a very long cover-plate where jointed. Dividing the thickness between two plates also gives the option of leaving one plate off where the boom load falls to a sufficiently low value.

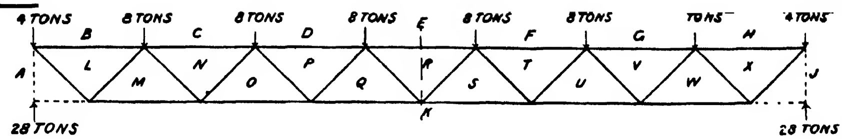
Covering Plates. In a girder of this length it is not convenient to obtain the boom sections in one length. Joints must therefore be designed and arranged, and the joint covers must have an equal area with the members which they cover. The flange-plate cover can be the same section as the flange plate—viz., 14 × ⅜ in., but the angle cover, having to lie in the hollow of the main angle, must be narrower in width by the thickness of the main angle. In this case a 4½ in. × 4½ in. × ⅝ in. angle will meet the conditions, and will give a net area of 9·5 sq. in., which is slightly in excess of what is required.

The length of a cover depends upon the number and pitch of rivets used. In the flange plate, 13 rivets, ⅞ in. diameter, will be necessary at 5 tons per square inch in shear; and, at 4 in. pitch, this works out to be a plate 4 ft. 7 in. long; in the angles 11 rivets, ⅞ in. diameter, will be found necessary, involving a length of 3 ft. 11 in. for the covering bar.

If desired, the outer flange plates could be left off when reaching bays CN, GV, MK, and WK, when the boom load drops to a quantity which a single flange plate and the angles can carry. It is, however, not usual to do this in small girders, as the level of the boom is thereby broken, and where superimposed girders occur, packings must be used to restore the level.

The maximum tie load occurs in LK and XK, and scales 34 tons. The area required at 6 tons per square inch is $\frac{34}{6} = 5{\cdot}7$ sq. in.; two 6 in. × ⅝ in. flat bars, with allowance made for a ⅞ in. rivet hole in each, gives 6·5 sq. in. area. The attachment at each end is by rivets in double shear, a ⅝ in. plate being sandwiched between the two tie bars and between the two main angles. The number of rivets required at 5 tons per square inch is eight.

The maximum strut load occurs in LM and WX, and scales 34 tons. The free length of the strut may be taken at 4 ft., and the minimum width, say, 4 in.; the ratio of depth to length is then $\frac{48}{4} = 12$ to 1. Using Gordon's formula for columns, having both ends fixed, this ratio gives a safe load of 4 tons per square inch, with a factor of safety of 5, then the area required $= \frac{34}{4} = 8{\cdot}5$ sq. in., which will be met by the gross area of two 5 in. × 4 in. × ½ in. tee bars, the riveted connection being the same as for the tie bar, the load being identical.



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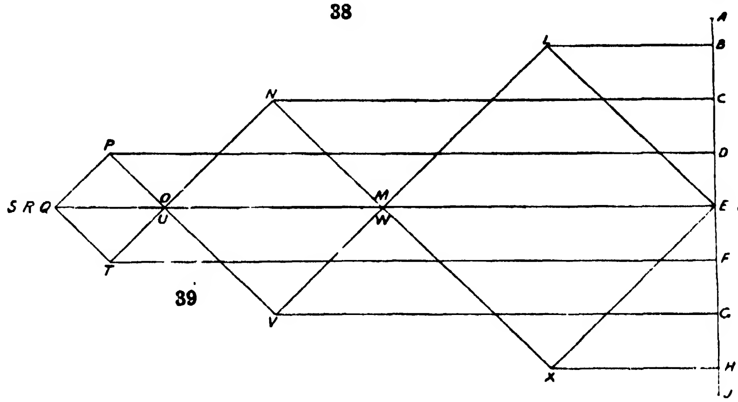

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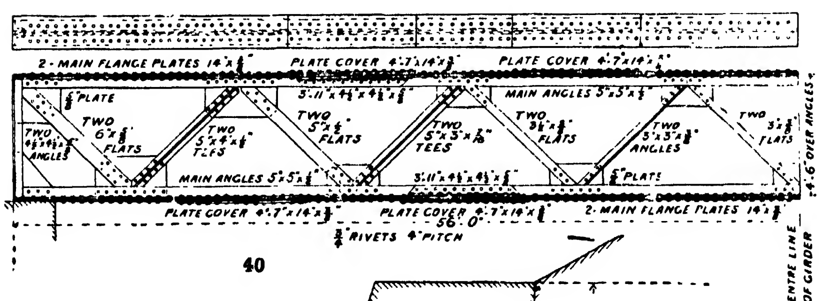

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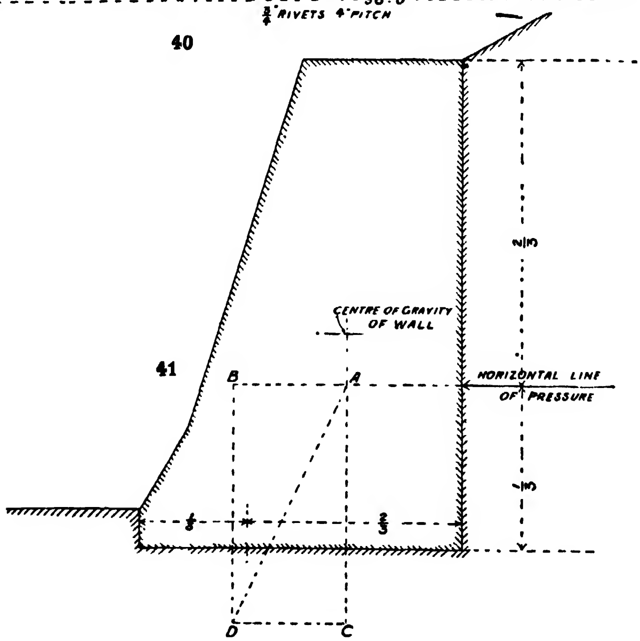

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STRESSES IN A WARREN GIRDER AND A DAM

Bearing Area. In designing riveted joints it is necessary to see that the rivets have sufficient bearing area as well as shearing area. For ordinary girder work an allowance of 10 tons per square inch is usual. This consideration frequently decides the thickness of the gusset plate. In the case in hand there are eight $\frac{3}{4}$ in. rivets in a $\frac{5}{8}$ in. plate, giving a total bearing area of $8 \times \frac{3}{4} \times \frac{5}{8}$ in. $\times\ 3\frac{3}{4}$ sq. in., a bearing stress of $\frac{34}{3{\cdot}75} = 9$ tons per square inch.

The remainder of the struts and ties are now designed to suit the loads that they have to sustain, and the drawing [**40**] is completed in accordance therewith.

We shall return to these examples immediately after having shown the application of force diagrams to a dam.

Dams. The parallelogram of forces is used to ascertain the stability of retaining walls, dams, etc. **41** illustrates the application. A section of the wall is drawn to a convenient scale, and its centre of gravity marked thereon. Drop a vertical line from the centre of gravity until it intersects the "horizontal line of pressure," marked off at one-third of the height of the wall. From this point (marked A) lay off the amount of the pressure in a line from A to B, then drop another line vertically from A to C equal in amount to the weight of the wall. These pressures are usually taken in units per lineal foot of wall. The parallelogram is then completed from C to D, and from D to B, and the resulting thrust is found upon joining the diagonal A — D. This line must, to ensure stability, pass well inside the base of the wall. If it pass outside the base the equilibrium is unstable. As a matter of fact, conditions in practice are so arranged that this line cuts the base within a point at not less than one-third of its length.

Examples from Practice. In the illustrations which have been given of crane framings, roofs, and framed girders, we have excellent examples of the remarks made in Article 2 on the applications of certain materials in certain ways.

The members in cranes are too numerous and varied to be taken in full detail here, but we may offer remarks on some of the more important of them.

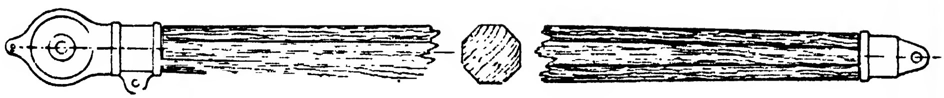
Referring to the crane framings in Article 3, we saw that while the jib is a compression member, the tie rods and the chain are subjected to simple tension. It is not quite correct to say that the jib is in compression absolutely. That is true only so long as it is not subjected to such excessive strain as would tend to flexure, and calculations on the strength of jibs are invariably made on this least favourable basis. That is, they are treated as long columns, which in case of fracture would fail by bending and not by crushing; and this is, in fact, what does happen, for when a jib fails, as it sometimes does, it becomes bent, and thus crippled.

Examples. But in order to prevent risk of such an event happening under proper conditions of working, long jibs are seldom made of parallel sections, but in other forms. They are *bellied*—that is, built of double parabolic form, the bases of two parabolas meeting at the middle of the jib. This design is used in light and heavy cranes alike. But while timber [**42**] is often used in the former, steel bracing [**43**] is adopted in the latter. The best examples of both of these jibs are found in the derrick cranes and wharf cranes. [It will be understood that though the jibs here shown are drawn as lying horizontally, for convenience of illustration, they stand at an angle of 45°, less or more, on their cranes.] The bellied form will be recognised as that of a beam loaded in the centre, and deepened there accordingly. But there is this difference, that while a beam is deepened in one direction only—that of its depth—the jib is enlarged depthwise, sideways, and diagonally, because the bending stresses come upon it in all directions in lifting, and in slewing sideways.

Alternatively, jibs are made of tapered outlines, the base or foot being considerably wider than the top end; or, in many cases, the tapered form is combined with the bellied, so resembling the tapering column having entasis. These outlines are also imparted to jibs made of timber [**44**] and of steel [**45**]. The latter occur in several designs, either solid plated, as in small cranes almost solely; or variously built up, and braced so as to lessen weight. In some of the heaviest cranes the jib has a large amount of tapering in both directions, perpendicularly as well as laterally, so much so, that the cross section of the framing at the foot becomes nearly square. This is also done to obtain great strength with comparatively little material, and such jibs have a very skeleton-like aspect, which seems hardly strong enough to sustain the loads of 40 or 50 tons which they carry safely. In many cranes the jibs are horizontal, instead of raking, like those shown in the illustrations. This form is introduced into cranes which have a travelling jenny, or a crab running in and out to different radii, resembling in this respect the traveller girders [**46** and **47**]. They are seldom solid plated, never in the large cranes, but are lattice braced. The design of such members in recent practice becomes more skeleton-like in appearance, being particularly noticeable in the long-armed cranes of American and German design, but they are nevertheless of ample strength for their duty.

Disposition of Materials. A timber jib [**42** and **44**] must of necessity be plain and solid. If in one piece, it is generally made octagonal in cross section [**42**]; or, if formed of two members, of rectangular section [**44**]; and it is sawn or adzed and planed to the tapering outlines. But the steel jib occurs, as already remarked, in many forms, and therein lies one of the numerous advantages that steel offers over timber for constructive purposes, and which we shall illustrate by practical examples throughout this course.

Take any of the shapes in which steel is rolled, and note their behaviour individually. Plates and bars are flexible, bending and falling about in all directions, destitute of a trace of rigidity



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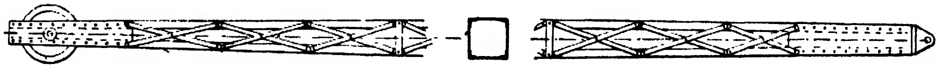

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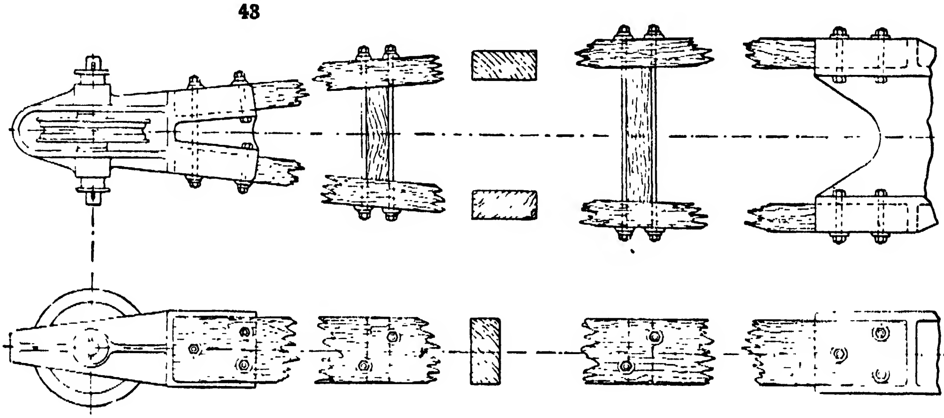

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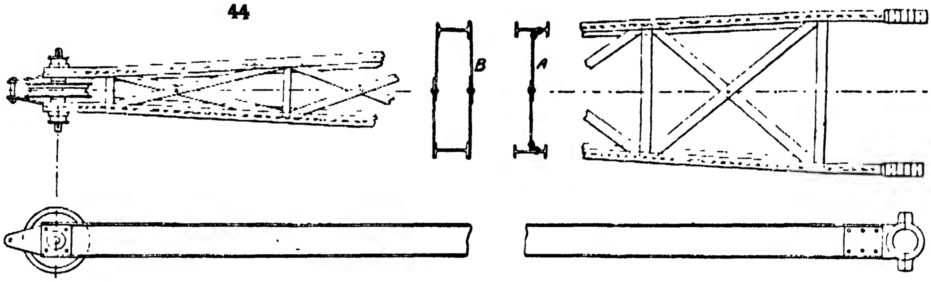

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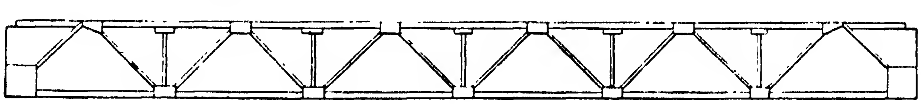

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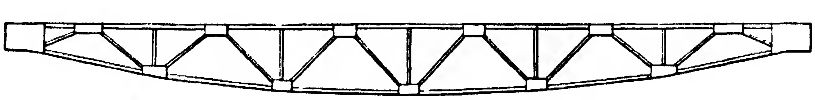

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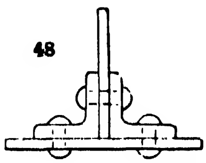
EXAMPLES OF CRANE JIBS AND TRAVELLER GIRDERS FROM PRACTICE

to withstand bending stresses. Actually, the thicknesses of single plates and bars in some girder-like structures is not much in excess of that of stout millboard; while by comparison with the dimensions of the entire structure they seem almost as thin as cardboard. But these can be so built up, as the bridge members are built up in the Warren [**40**] and other girders, as to render some elements helpful to others by affording them ample stiffness, which assistance is mutual.

The simple case of two thin bars or plates set at right angles makes a rigid combination [**48** and **49**]. This device is carried out in several designs, not only in built-up or plated work, but in what are termed rolled sections, as angles [**50**], tees [**51**], channels [**52** and **53**], joists, or H sections [**54** and **55**], and others. These give the designer



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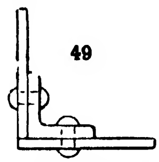

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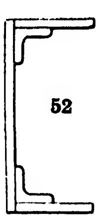
the means of obtaining maximum strength with minimum weight and expense.

No work of this kind is solid or cubical like timber is, but it has either a sectional form which embodies the web and flange type, as at A—the section of the jib shown in **45**—or the box type B also in **43**. The latter may be either plated, or open webbed—termed *lattice braced*, as shown. The bounding outlines of these structures are generally rectangular. But the point is that the metal is mostly massed outside, and the interior is entirely hollow, or it is webbed, and that is where the neutral axis of no strain lies. And thus it comes about that materials which in their elementary sections appear to be the least suited to



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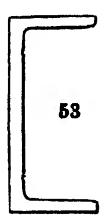

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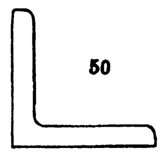
withstand compression or bending stresses are rendered as rigid as timber or cast iron, besides being much stronger and better qualified than these to resist stresses that tend to pull asunder or to bend.

The writer remembers old cranes in which jibs of cast iron were actually used, because adapted to resist compressive stresses. But at that time wrought iron was used only to a slight extent in large rolled sections, and the science of braced structures was not then understood as it is to-day.

Cast-iron Fittings. Before we leave the jibs we must point out illustrations of the union of two kinds of materials in one member—namely, mild steel and cast iron, a combination alluded to in the second article. Many jibs must have some castings fitted to serve as attachments to parts of the crane adjacent, and to carry pin bearings. The thickness of the steel plate (from $\frac{1}{4}$ to $\frac{1}{2}$ in.) does not always afford sufficient bearing surface for fastenings or pins, and therefore cast-iron fittings are attached at the foot and head, and sometimes elsewhere, depending on the design. Such fittings, being in compression, are therefore, apart from convenience in manufacture, very properly made of cast iron. Examples of these are seen in **42**, **43**, **44**, and **45**, a few only out of many designs easily obtainable by casting, but very difficult and costly to produce by forging or plating. In some cases the castings fulfil the purpose of rigid ties to the end of the otherwise unsustained plated work.



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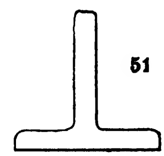

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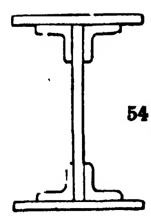
The chain pulleys of the jibs [**42** to **45**] are subjected only to compression, and are therefore of cast iron. Their pins are in shear, or more often combined shear and bending, and these, therefore, are made in mild steel.

Tension Rods. Turning to the tie-rods [**56**], which are subjected wholly to tension, several things have to be considered. There is not only the rod itself, but its method of attachment. It is absolutely essential that the material must not only be strong, but tough, and capable of stretching. Practically only two materials fulfil these conditions—wrought iron and mild steel. The former has a strength equal to about 22 tons per square inch, the latter equal to 28



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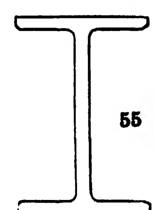

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or 30 tons. The first will stretch from 7 to 9 per cent. in a length of 10 in. previous to fracture; the second from 20 to 25 per cent. in the same length.

It is hardly necessary to point out how valuable is this property of stretching considerably before fracture in structures that are subjected to severe tension. Cast iron snaps without giving the slightest previous warning, which bars its use in tension elements, unless an enormous factor of safety is allowed.

A tie-rod is subjected to severe stresses, due to the sudden surging and jerking of loads, and therefore a high factor of safety is essential, from eight to ten in excess of the actual stress that would snap the rod by a steady pull, such as

would be imparted at the testing machine. And, of course, the work being divided between two rods—except in some very small cranes—the cross section of each rod is one-half that required for the pull allowed for.

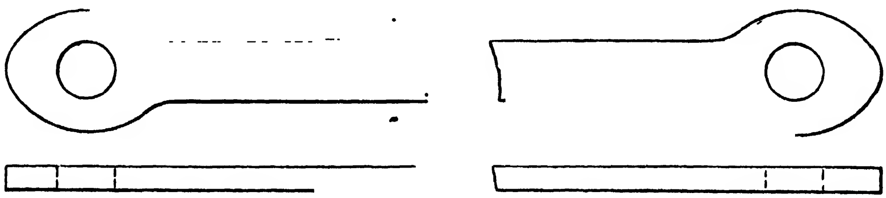
The Fastening of Rods. An important detail is that the rods should be as strong at the location of the attachment as they are throughout their parallel length. They are attached either by eyes or screws. The metal in the eyes being in direct tension, its total cross section [**56**] must be at least equal to that of the body of the rods. Generally, it is made a little in excess, for security. And, to prevent risk of the metal being torn out at the end, it is generally elongated, which explains why tie-rod eyes are usually of elliptical rather than circular form [**56**].

When rods with screwed ends are attached, the diameter of the screw-thread must be greater than that of the rod [**57**], because if screwed on the same size, the root of the thread will be smaller than the rod, and fracture would certainly take place through the bottom of the threads. This explains the reason for the swelled screwed ends seen on such rods.

Chains. It is necessary that the other main tension member in a crane—the chain—should be flexible; but with this exception similar conditions have to be fulfilled as in the rigid tension-rods. High ductility, a high factor of safety, and secure and strong attachments have to be ensured. Its strength is, of course, equal to that given by the two transverse sections of the iron in the links. As every link is closed by welding, wrought iron is used for chains rather than mild steel, because welds in the latter are not so reliable as those in iron. Chain links are strained if bent over pulleys of small diameter, they also deteriorate much in service, suffering from fatigue. Their strength can be restored by annealing. But these evils explain why the smaller and more flexible wire-rope is being extensively used in preference to the more rigid chain links. The strain in chain and ropes is alike throughout—that is, the fact of passing over a pulley only alters the direction of motion, it does not alter the stress.

Chains, or wire ropes, are frequently used instead of rigid tie-rods for derricking cranes, or lengths of chain and rigid tie-rod are linked together to form one tension member.

Roof Trusses. Passing from the crane diagrams to those of roof trusses [37], illustrated in the last article, we find that similar devices are embodied. The tension members are composed of flat bars only, because, being in simple tension, the strength of the cross section alone has to be considered. That is, a cross section of, say, $2\frac{1}{2}$ in. × $\frac{5}{16}$ in. has been calculated to withstand the purely pulling stress to which the member will be subjected, plus the factor of safety. There is no question of bending in these tension members, so that the flat bars do not require stiffening. Though flexible in themselves, the stress imposed maintains them in a taut condition always.



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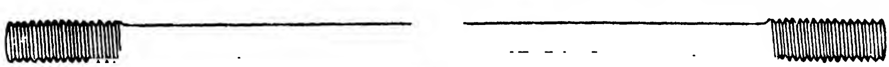
But now note the compression members. These are formed of rolled tees, or T sections. In heavy work they are built up of flats and angles [**48** and **49**], for reasons to be noticed presently. But the point is that, being subject to compression, such members must be capable of resisting bending stresses, as in the crane jibs now illustrated, due to their great excess of length over section. Actually, therefore, they are not strictly compressive members, and if their strength were calculated as such they would fail by bending. They behave as long columns pivoted at the ends. They are, therefore, beams, the webs of which offer resistance to flexure in directions at right angles with each other. The student, looking at a steel roof, can always distinguish the tensile from the compressive members by observing the differences in their cross sections.

Wide Utilities of the Foregoing. In structures a thousand changes are rung on these simple elementary designs, derived from flat bars variously arranged. The rolled section is simply a cheap method of obtaining what is got at more expensively by building up with bars and angles. But it is necessary to adopt the latter in heavy structures for a reason already given—namely, the lessening of weight.



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The strength of beams increases directly as the *thickness* of the web, but as the square of the *depth*. Weight is therefore lessened by lessening thickness, and strength is increased by adding to the depth. A lighter but stronger structure can therefore be obtained by riveting two thin bars at right angles with angle irons than by using a rolled section.

To be continued

Group 21

MATHEMATICS

4

Continued from page 348

FRACTIONS

Reduction to Lowest Terms. Comparison of Fractions. Addition, Subtraction and Multiplication. Examples

By HERBERT J. ALLPORT

EXAMPLES 9

1. Which of the following numbers are prime? 587, 745, 1073, 997.
2. Find the H.C.F. of (i) 165, 341, and 1302; (ii) 19769 and 36181.
3. Find the L.C.M. of (i) 18, 21, 24, 30, 36, 49; (ii) 1581 and 1887; (iii) 2520, 3315, and 5265.
4. Find the least number of lb. Avoirdupois which can be expressed as an exact number of lb. Troy.
5. Find the least number which, when divided by 42, 63 or 81, always leaves remainder 40.
6. A number of pencils can be tied into bundles of 17; but if they are tied in bundles of 8 or of 9, there is one pencil left over in each case. Find the least number of pencils.
7. Four bells ring simultaneously, and afterwards at intervals of 2, 3, 5 and 9 seconds respectively. How long will it be before they all ring together again?
8. From a heap of silver coins, all of the same sort, which weighs 38·875 kilogrammes, another heap weighing 2·605 kilogrammes is taken. Find the greatest possible weight of a single coin.
9. Two men, the lengths of whose strides are 30 and 33 inches respectively, start walking together at the same rate. How often will they be in step in walking a mile?

FRACTIONS

69. An *integer*, or *whole* number, is a number which consists of a collection of complete units.

A *fraction* is a quantity less than the unit. We have already seen (Art. 29), how quantities less than the unit can be expressed in the decimal notation. When so expressed, they are called *decimal fractions*.

70. We shall now consider another method of expressing fractions. Suppose that any unit is divided into 7 equal parts. Each of these parts is called one-seventh, and is denoted by $\frac{1}{7}$; two of the parts make two-sevenths, or $\frac{2}{7}$; three of the parts make three-sevenths, or $\frac{3}{7}$, and so on.

Thus, we see that a fraction is expressed by two numbers, written one above the other and separated by a line. The lower number shows the number of equal parts into which the unit is divided. Since it gives a *name* to the parts, it is called the *Denominator*. The upper number is called the *Numerator*, since it tells us the *number* of equal parts taken to form the fraction.

Fractions expressed in the above manner, such as $\frac{5}{9}$, $\frac{11}{43}$, $\frac{51}{8}$, are called *Vulgar—i.e., Common Fractions.*

71. A *Proper Fraction—i.e.*, a quantity which, in accordance with our definition, is *part* of a unit, will evidently have its numerator less than its denominator.

If, after dividing the unit into any particular number of equal parts, say 15, we take more than 14 of such parts, say 17, we obtain a quantity equal to seventeen fifteenths of the unit, or $\frac{17}{15}$. Such a quantity, which must evidently be not less than the unit, is called an *improper* fraction. Thus, in an improper fraction, the numerator is not less than the denominator.

72. A *mixed number* is the sum of a whole number and a fraction.

Thus, the sum of 4 and $\frac{5}{8}$ is a mixed number. It is written $4\frac{5}{8}$.

A mixed number can always be expressed as an improper fraction.

Example. Reduce $5\frac{4}{9}$ to an improper fraction.

Each unit of the 5 contains 9 ninths.

$\therefore$ 5 units contain $5 \times 9 = 45$ ninths.

Thus $$5\frac{4}{9} = \frac{5 \times 9 + 4}{9} = \frac{49}{9} \quad \textit{Ans.}$$

Again, an improper fraction is converted into a mixed number by dividing the numerator by the denominator. The quotient will be the whole number, and the remainder will be the numerator of the proper fraction.

Example. Express $\frac{43}{5}$ as a mixed number.

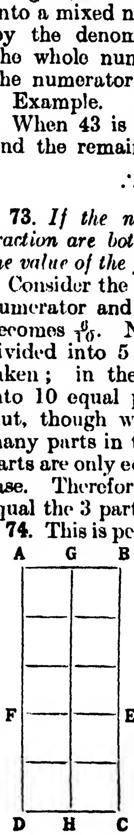
When 43 is divided by 5, the quotient is 8, and the remainder 3.

$$\therefore \frac{43}{5} = 8\frac{3}{5} \quad \textit{Ans.}$$

73. *If the numerator and denominator of a fraction are both multiplied by the same number the value of the fraction is not altered.*

Consider the fraction $\frac{3}{5}$. If we multiply both numerator and denominator by 2, the fraction becomes $\frac{6}{10}$. Now, in the fraction $\frac{3}{5}$, the unit is divided into 5 equal parts and 3 of these are taken; in the fraction $\frac{6}{10}$ the unit is divided into 10 equal parts and 6 of them are taken. But, though we divide the unit into twice as many parts in the second case, yet two of these parts are only equal to one of the parts in the first case. Therefore, the 6 parts in the second case equal the 3 parts in the first—*i.e.*, $\frac{3}{5} = \frac{6}{10}$.

74. This is perhaps made plainer by a diagram.



Let A B C D represent the unit. Divide this into 5 equal parts by drawing lines parallel to A B. Then A B E F, consisting of 3 of these strips, will represent $\frac{3}{5}$ of the unit.

Now divide A B C D into 10 equal parts by drawing a line parallel to A D. Then A B E F contains 6 of these parts, and therefore represents $\frac{6}{10}$ of

the unit. Hence, since A B E F represents both $\frac{3}{5}$ and $\frac{6}{10}$, it follows that $\frac{3}{5} = \frac{6}{10}$.

75. We have shown that $\frac{6}{10}$ and $\frac{3}{5}$ are equal.

Now, $\frac{3}{5}$ is obtained from $\frac{6}{10}$ by *dividing* both numerator and denominator by 2. Hence, the statement in Art. **73** is also true if we substitute "divided" for "multiplied." Therefore, the numerator and denominator of any fraction may always be divided by any common factor that they contain.

When we have divided out (or *cancelled*), all the common factors of the numerator and denominator, the fraction is said to be ***in its lowest terms***.

76. Reduction to Lowest Terms. In finding the common factors of the numerator and denominator the rules given in Art. **56** should be applied. When, however, common factors cannot easily be seen, it is better to find at once their H.C.F. by the ordinary rule.

Example 1. Reduce $\frac{5115}{11880}$ to its lowest terms.

Here $\frac{5115}{11880} = \frac{1705}{3960}$ (dividing numerator and denominator by 3),

$= \frac{341}{792}$ (dividing by 5),

$= \frac{31}{72}$ (dividing by 11).

Now, 31 is a prime number, and it does not divide 72,

$\therefore \frac{31}{72}$ is in its lowest terms.

Example 2. Reduce $\frac{1582}{10057}$ to its lowest terms.

By trial, 2, 3, 5, 7, 11, 13 are none of them common factors, so we find the H.C.F.

2	1582	10057	6
4	452	565	1
	...	113	

The H.C.F. is 113. Divide numerator and denominator by 113. The quotients are 14 and 89,

$\therefore \frac{1582}{10057} = \frac{14}{89}$ *Ans.*

H.C.F. working can be more compactly arranged than by the method in Art. **60**. Here, the first remainder is 565. We now divide this into 1582, writing the quotient, 2, on the left. Remainder is 452. Divide this into 565, putting the quotient on the right; and so on.

77. Any fraction can be expressed with a denominator which is any given multiple of its original denominator.

Example 1. $\frac{3}{4}$ can be expressed with denominator 7 × 4.

Thus $\frac{3}{4} = \frac{7 \times 3}{7 \times 4} = \frac{21}{28}$; for the value of the fraction is not altered when we multiply both numerator and denominator by 7.

It is now clear that any number of fractions can be expressed as fractions with a denominator which is some *common* multiple of the original denominators. It is generally most convenient to use the *least* common multiple.

Example 2. Reduce $\frac{3}{7}$, $\frac{5}{14}$, $\frac{8}{21}$ to a common denominator.

The L.C.M. of 7, 14, 21 is 42. Therefore, we express each fraction as a fraction with denominator 42.

Thus $\frac{3}{7} = \frac{3 \times 6}{7 \times 6} = \frac{18}{42}$,

$\frac{5}{14} = \frac{5 \times 3}{14 \times 3} = \frac{15}{42}$,

$\frac{8}{21} = \frac{8 \times 2}{21 \times 2} = \frac{16}{42}$.

The multiplier for each fraction is, of course, found by dividing its denominator into the common denominator 42.

78. Comparison of Fractions. When we have reduced any given fractions to a common denominator, we see at once that the one with the largest numerator is the greatest fraction. For instance, in Ex. **2** of the last article, the three fractions were found equivalent to $\frac{18}{42}$, $\frac{15}{42}$, and $\frac{16}{42}$. But $\frac{18}{42}$ is greater than either $\frac{15}{42}$ or $\frac{16}{42}$—*i.e.*, $\frac{3}{7}$ is the greatest of the given fractions.

Example. Arrange in ascending order of magnitude,

$\frac{13}{15}, \frac{11}{14}, \frac{31}{35}, \frac{17}{21}$.

Find L.C.M. of denominators:

3	15, 14, 35, 21
7	5, 14, 35, 7
	2, 5

L.C.M. = 3 × 7 × 2 × 5 = 210.

$\frac{13}{15} = \frac{13 \times 14}{15 \times 14} = \frac{182}{210}$; $\frac{11}{14} = \frac{11 \times 15}{14 \times 15} = \frac{165}{210}$;

$\frac{31}{35} = \frac{31 \times 6}{35 \times 6} = \frac{186}{210}$; $\frac{17}{21} = \frac{17 \times 10}{21 \times 10} = \frac{170}{210}$.

Therefore, the fractions in ascending order are

$\frac{165}{210}, \frac{170}{210}, \frac{182}{210}, \frac{186}{210}$;

or, $\frac{11}{14}, \frac{17}{21}, \frac{13}{15}, \frac{31}{35}$ *Ans.*

79. We can also compare the magnitude of fractions by reducing them to a common *numerator*, in which case the fraction with the *least* denominator is the greatest fraction.

Example. Which is greater, $\frac{3}{7}$ or $\frac{2}{5}$.

Here, L.C.M. of the numerators is 6,

and $\frac{3}{7} = \frac{3 \times 2}{7 \times 2} = \frac{6}{14}$,

$\frac{2}{5} = \frac{2 \times 3}{5 \times 3} = \frac{6}{15}$;

$\therefore \frac{6}{14}$, *i.e.*, $\frac{3}{7}$, is the greater fraction.

80. Addition of Fractions. If two or more fractions have the same denominator, their sum is obtained by adding the numerators.

Thus, $\frac{1}{7} + \frac{4}{7} + \frac{5}{7} = \frac{1+4+5}{7} = \frac{10}{7} = 1\frac{3}{7}$.

If the fractions have different denominators, we must first express them as equivalent fractions with the same denominator. (Art. **77**).

Example 1. Find the value of

$$\frac{1}{9} + \frac{3}{7} + \frac{5}{21} + \frac{2}{3}.$$

The L.C.M. is 63. The several denominators, when divided into 63, give 7, 9, 3, 21 respectively, for quotients. Therefore, we multiply the numerators and denominators of the fractions by 7, 9, 3, 21, and add the numerators to obtain the required sum. The result must be reduced to a mixed number, or to lower terms, if necessary.

The work is arranged thus:

$$\frac{1}{9}+\frac{3}{7}+\frac{5}{21}+\frac{2}{3},$$
$$=\frac{7+27+15+42}{63}$$
$$=\frac{91}{63}=1\frac{28}{63}=\underline{1\frac{4}{9}\ \textit{Ans.}}$$

In adding mixed numbers, first add the whole numbers, then the fractions, finally adding the two results.

Example 2. Add together $3\frac{1}{8}+\frac{7}{24}+7\frac{11}{15}+4\frac{3}{20}$.

Given expression

$$=3+7+4+\frac{1}{8}+\frac{7}{24}+\frac{11}{15}+\frac{3}{20},$$
$$=14+\frac{15+35+88+18}{120},$$
$$=14+\frac{156}{120}=14+1\frac{36}{120}=\underline{15\frac{3}{10}\ \textit{Ans.}}$$

81. Subtraction of Fractions. The principle is the same as in addition. Reduce the fractions, if they have different denominators, to a common denominator, and then take the difference of the numerators. In the case of mixed numbers, subtract the whole numbers and the fractions separately.

Example 1. Take $4\frac{5}{21}$ from $6\frac{3}{7}$.

$$6\frac{3}{7}-4\frac{5}{21}=6-4+\frac{3}{7}-\frac{5}{21},$$
$$=2+\frac{9-5}{21},$$
$$=2+\frac{4}{21}=\underline{2\frac{4}{21}\ \textit{Ans.}}$$

If the fractional part of the number to be subtracted be greater than the fractional part of the other number, we proceed as follows:

Example 2. From $7\frac{4}{15}$ take $4\frac{11}{25}$.

$$7\frac{4}{15}-4\frac{11}{25}=7-4+\frac{4}{15}-\frac{11}{25},$$
$$=3+\frac{20-33}{75},$$
$$=2+\frac{75+20-33}{75},$$
$$=2+\frac{62}{75}=\underline{2\frac{62}{75}\ \textit{Ans.}}$$

Example 3. Simplify $3\frac{2}{9}+4\frac{5}{7}-5\frac{13}{21}+\frac{2}{35}-1\frac{14}{15}$.

Given expression

$$=3+4-5-1+\frac{2}{9}+\frac{5}{7}-\frac{13}{21}+\frac{2}{35}-\frac{14}{15},$$
$$=1+\frac{70+225-195+18-294}{315}$$
$$=1+\frac{313-489}{315},^{*}$$
$$\frac{628-489}{315}=\frac{139}{315}\ \underline{\textit{Ans.}}$$

82. Multiplication of Fractions. (i.) When the multiplier is a whole number. This, as in the case of whole numbers (Art. 15), means that we have to find the *sum* of a given number of repetitions of the fraction.

* Obtained by adding all the numerators with + before them, and then all those with − before them.

Example 1.

$$\frac{7}{9}\times 4 \text{ means } \frac{7}{9}+\frac{7}{9}+\frac{7}{9}+\frac{7}{9},\ \textit{i.e.,}\ \frac{28}{9};$$

or

$$\frac{7\times 4}{9}.$$

Hence, *to multiply a fraction by a whole number, simply multiply the numerator by that number.*

Since the multiplier thus becomes a factor of the numerator, we *cancel* (Art. 75) any common factors contained in the multiplier and the denominator; and this may be done *before* we perform the actual multiplication. Thus:

Example 2. Multiply $\frac{19}{46}$ by 69.

$$\frac{19}{46}\times 69=\frac{19\times 69}{46}=\frac{19\times 3}{2}\ \text{(cancelling 23)},$$
$$=\frac{57}{2}=\underline{28\frac{1}{2}\ \textit{Ans.}}$$

It follows, that, if the multiplier be itself a factor of the denominator, we may, *to multiply a fraction by a whole number, divide the denominator by that number.*

(ii.) When the multiplier is a fraction.

In performing the operation 7×9, it is plain that we do to 7 what we do to a unit to obtain 9. Similarly, $\frac{3}{5}\times\frac{4}{11}$ may be looked upon as doing to $\frac{3}{5}$ what we do to the unit to obtain $\frac{4}{11}$.

Now, to obtain $\frac{4}{11}$ from the unit, we must divide the unit into 11 equal parts and take 4 of them.

Therefore, to find the value of $\frac{3}{5}\times\frac{4}{11}$ we must divide $\frac{3}{5}$ into 11 equal parts and take 4 of them.

But $\frac{3}{5}=\frac{33}{55}$ (Art. 73) $=\frac{3}{55}\times 11$ (Art. 82, i), so that, the eleventh part of $\frac{3}{5}$ is $\frac{3}{55}$; and, if we take 4 of these parts, we get $\frac{3}{55}\times 4$, or $\frac{12}{55}$.

Thus, $\frac{3}{5}\times\frac{4}{11}=\frac{12}{55}$. Now $12=3\times 4$, and $55=5\times 11$.

Hence we have the following rule: *To multiply two fractions together, multiply the numerators for a new numerator and the denominators for a new denominator.*

As in Ex. 2 the work is shortened if we cancel common factors from the numerators and denominators.

Example 3. Multiply $\frac{22}{91}$ by $\frac{13}{77}$.

$$\text{The product}=\frac{\overset{2}{\cancel{22}}\times\cancel{13}}{\underset{7}{\cancel{91}}\times\underset{7}{\cancel{77}}}=\underline{\frac{2}{49}\ \textit{Ans.}}$$

Here, the 22 of the numerator and the 77 of the denominator contain a common factor, 11. Therefore, we cross out the 22 and write 2 above it, and cross out the 77 and write 7 under it. Similarly, we cancel the factor 13 from 13 and 91. There is now 2 left for numerator and 7×7 for denominator.

To multiply more than two fractions together, we proceed in the same way.

In multiplication of fractions, mixed numbers must first be expressed as improper fractions.

Example 4. Simplify $5\frac{1}{7}\times\frac{11}{27}\times 1\frac{11}{24}$.

$$\text{Given expression}=\frac{\overset{\cancel{4}}{\cancel{36}}}{\cancel{7}}\times\frac{11}{\underset{9}{\cancel{27}}}\times\frac{\overset{5}{\cancel{35}}}{\underset{2}{\cancel{24}}},$$
$$=\frac{55}{18}=\underline{3\frac{1}{18}\ \textit{Ans.}}$$

To be continued

THE THREE LAWS OF MOTION

Newton's Laws—continued. **Their operation as manifested in the Sun, the Omnibus, and the Cricket Ball. Interplay of Nature's Laws. Equilibrium**

By DR. C. W. SALEEBY

We cannot leave the first law of motion without inquiring whether there is any known case of perpetual motion—the words being used in their legitimate but ignored sense—or of anything that closely approaches it. In our search for such a case we must leave all cases of motion through a thick resisting medium, and must therefore abandon all cases of motion on the earth. Similarly, even the top revolving in a perfect vacuum (if that could be obtained) would not satisfy us, for the top has to be supported upon something, and this introduces friction.

The Motion of the Earth. But if we take the earth itself, we have a moving object which is not supported upon anything, and which moves through—what? If it moved through *nothing*, we should have to believe that its movement must be an instance of perpetual motion. For ages this planet "has gone cycling on according to the fixed laws of gravity"—to quote from the famous last paragraph of Darwin's "Origin of Species"—and since there is no such thing as a tendency to stop, but rather a tendency to go on unless stopped, why should it not so go "cycling on" for ever, there being nothing to stop it?

But to this we must answer that though the earth (including, of course, its atmosphere, which, fortunately for us, it does not leave behind) meets with very little resistance, yet it is moving through a medium which is called the *ether*. We use the ether as a symbol for fineness of texture and for tenuity (the opposite of density), as when those who believe in them speak of ghosts as of "ethereal texture"; but however tenuous the ether, yet it *exists*, and must offer some resistance to the earth's movement.

This is a subject now engaging the attention of the astronomical physicists. Further, it has lately been proved that light and all the radiations in the ether that are comparable with light, though they happen to be invisible to us, exercise a pressure or force upon the earth which must be slowly affecting its onward motion.

The Rotation of the Earth. But the reader may be inclined to suggest that, though the earth may meet with external force of opposition in its movement of translation, it must at any rate be free to exhibit perpetual motion and illustrate Newton's first law, in so far as its movement of rotation is concerned. Must it not go spinning for ever, even though its movement round the sun should be arrested? Is not the earth like a top which spins not only in a vacuum, but without friction, since it is without material support?

The answer to this is that even the rotation of the earth does not furnish us with the case of perpetual motion that we seek, for, apart from any friction between the rotating earth and the ether, Professor George Darwin (the son of Charles Darwin and President of the British Association in 1905) has proved that the friction of the tides acts as a brake upon the rotation of the earth; so that this rotation is becoming slower, and thus the day is lengthening by about 22 seconds in every century. This may sound very little, but consider the difference it will mean in, say, 100,000 years.

The Force in a Moving Body. Further we must note that the discovery of the pressure of light makes necessary a very curious practical addition to the first law of motion. Indeed, this law is never illustrated in actual practice, not because the law is not true, but because of the occurrence of factors of complication. The law declares that a moving body will move in a straight line with a constant velocity for ever unless it be acted upon by some external force.

But we are actually now compelled to declare that the law must be restated, for we find that the moving body contains within itself a force which tends to stop it. The tendency to stop, to which we have so often pointed as at a superstition, has some correspondence to fact, after all, though this correspondence is very different from that commonly supposed. Take, for instance, the sun, or any body radiating light, heat, or any form of ethereal radiation. This category probably includes all bodies whatever, whether in the earth or in the heavens, and certainly it includes the cricket-ball, which we have considered; but we will choose the sun as most convenient for our purpose.

The Sun Moving through Space. As the sun moves through space, with his family, he radiates light and heat in all directions, and it has been proved that this light and heat exercise actual pressure, as we shall see in a later section. But when we consider the case of the sun, or any moving radiant body, we see that he tends to "catch up" the waves which he sends in front of him, whilst those he sends out from behind him increase their distance from him with additional speed, due to the fact that he is moving away in the opposite direction from them. Hence the waves of radiation are packed close in front of the sun and thinned out behind him; and it follows that the *radiation-pressure* is greater in front than behind. Therefore the sun, in virtue of a force which he himself produces, *tends to stop*. The reader will not be confused; he will not regard this as a "tendency to stop" without there being something to do the stopping. If it were so, the first law of motion, and the conservation of energy, would be nonsense. But it is a remark-

able discovery that the first law of motion can never apply to existing things, but only to an imaginary state of affairs, since its action must always be compromised by the action of the remarkable law, in virtue of which every moving body that produces ethereal radiations (that is to say, so far as we can judge, every moving body at all) actually produces in its surroundings such conditions of external force as tend to bring about its own arrest. The first law of motion is no more to be regarded as untrue on this account than the law of gravitation is to be accounted untrue because the earth does not instantly rush into the sun. Each law is true, as a statement of what would and must occur, if no other law had to be recognised.

Interplay of Nature's Laws. The actual facts of Nature are due to the interplay of innumerable laws, and it is our business both to recognise the interplay and to disentangle the various laws if we can. Of such disentangling the discovery of the first law of motion is a great example—an example all the greater and all the more important because, so far as we know, there is in Nature no case whatever of the uncomplicated action of this law. Observe the word uncomplicated. The law is true everywhere and at all times, even though no obvious illustration of its truth can be furnished; otherwise it is not a law of Nature. In a famous controversy, Charles Kingsley, the great divine, declared that he defied and nullified the law of gravitation by his will, when he held an object in his hand, and prevented it from falling. He did nothing of the sort. The law of gravitation was strictly observed, and was expressed in the weight or pressure of the object in Kingsley's hand. Similarly, the first law of motion is as surely in action when a cricket-ball stops rolling as it would be if the cricket-ball, in the absence of friction or external resistance, went on moving for ever.

Everyday Illustrations. We may conclude our consideration of the first law of motion by one or two illustrations of its action in daily life. We shall look not at the conventional illustrations, but at others which are more vivid.

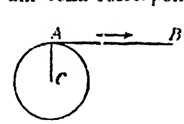
For instance, let us suppose that a man is standing on the top of a 'bus, when the conductor gives the signal to start. Everyone knows that the passenger is liable to fall backward. Why? He is in a state of rest, and in order to move forward a force must be applied to him. If his boots were so smooth, and the top of the 'bus so smooth, and his weight so negligible that friction played no part, the passenger would simply slide—not fall—backward along the top of the 'bus. But in virtue of friction, the force exercised by the horses or the motor is communicated to him. The first part of his body to be impressed by the external force is the lower, which moves forward, leaving behind the upper portion, which, deprived of support, falls vertically downward behind the advancing legs. That is to say, the passenger falls backward.

But suppose the passenger be riding in a hansom and the horse falls. As everyone knows, he lands on the horse's back. Why? Because, in virtue of the first law of motion, his body continues to move forward, though the seat which supported it happens to stop. If the earth lost its powers of gravitation, and the air had no resistance, the passenger would be propelled in a sitting position through space for ever, free of charge.

Jumping off a 'Bus. Other illustrations are furnished by the modes of jumping off a 'bus. Assume that the step of the 'bus is at the back, instead of the side. The wise passenger may step off such a 'bus on to one foot, and stand upon it without needing even to put down the other —if he will attend to the first law of motion. As he leaves the 'bus, his whole body is in forward motion at the speed possessed by the 'bus. The foot which touches the ground is arrested by friction. If the passenger's body be vertical when he steps off, the upper part of his body, continuing to move forward in accordance with the law, will inevitably be overbalanced, unless he rapidly advances the free leg to save himself. But he can perform the feat named, if he steps off the 'bus with the upper part of his body inclined so far backward that he would fall backward were the 'bus stationary. For, if the 'bus be moving, his whole body is moving. The lower part is arrested, the upper continues to move forward, and, if properly inclined backward at the moment when the foot touched the ground, will be arrested just when it has travelled so far forward as to be immediately above the already arrested leg.

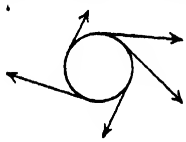
Similarly, it is easy to step from a rapidly moving 'bus, with the face turned backward, if one remembers to fall in the direction of the face as one steps off. The upper part of the body travels onward—instead of falling on one's face, one is left standing upright.

Tangential Motion. The law also explains the fashion in which rain-drops may be whisked off an umbrella by rotating the handle. If this be done very slowly, the force of cohesion between the drops and the silk is enough to keep them in their place. But as soon as the umbrella is rotated fast enough, the force of cohesion fails, and the moment the drop ceases to be in actual contact with the umbrella it obeys the first law of motion, and moves not in a circle but in a straight line; it *flies off at a tangent*. This has become a phrase of common speech, but it is strictly true. At any given moment, each rain-drop is moving in a direction which may be represented by a tangent to the circle to which the edge of the umbrella corresponds.

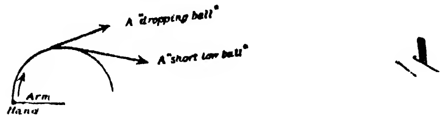


We remember that a tangent (literally a *thing touching*) is a line which touches the circumference of a circle, and is at right angles to that radius of the circle which is drawn from the point of contact. Observe that, in virtue of the first law of motion, the departing drops do not continue to move in circles, but in straight lines. The

accompanying figure represents their course, each line being a tangent to the circle at the point where cohesion failed to control the motion of a drop. Compare a "St. Catherine's wheel."



For a last illustration we may return to cricket. The ball leaving the hand of an over-hand bowler flies off at a tangent from the circle which his arm describes. Hence the path of the ball is determined by the earth's gravitation and the moment when the ball leaves the hand. The higher the ball's flight, the earlier did it leave the bowler's hand.



The bowler who has no control over "pitch" is one who cannot control the moment at which he lets the ball go from his hand, and thus cannot determine the tangent which it follows. It need hardly be said that, were there no force of gravitation and of aerial resistance complicating the action of the first law of motion, the high "dropping" ball of the diagram would never drop, but would travel in the straight line represented by the tangent at constant speed for ever. It would be a unique case of six "wides" for "lost ball"!

The Second Law of Motion. We must now pass to the consideration of the *second law of motion.* This may be stated in many different forms, but perhaps as intelligible as any is the following: Change of *momentum* is proportional to the impressed force, and takes place in the direction in which the force acts.

Before we go any further it is necessary to know the meaning of the word momentum. It is practically equivalent to quantity of motion, so that the law might be changed so as to read: Change of quantity of motion is proportional, etc. What, then, do we mean by quantity of motion? The term is to be strictly defined: The quantity of motion of any body is proportional to its mass and its velocity taken together. If we use a capital "M" to signify momentum, a small "m" to signify mass, and a small "v" to signify velocity, we may frame the formula

$$M = mv.$$

But we must have a little more definition yet. Hitherto we have used the words speed and velocity indifferently, but from this moment we must employ the word velocity with its strict technical meaning. In physics *velocity* is taken to mean speed—that is to say, rate of motion *plus the statement of the direction of the motion.* Velocity is therefore speed plus direction; thus we see that

Momentum equals mass and velocity, or equals mass and speed and direction.

We are now in a position to read the second law of motion with full comprehension.

It means that the change in the quantity of motion of a moving body, and in the direction of its motion, is strictly determined by the quantity and the direction of the force which causes it. In this law is included the principle discovered by Galileo—whom we have already described as the father of dynamics—the principle of the independence of two or more forces that may act on a body. It is true that the body moves only in one direction at one time, though acted upon by fifty forces, yet each of these forces determines the momentum of the body in its own measure, as Galileo showed.

Composition and Resolution of Forces. It is from this second law of motion that we are able to deduce the means of compounding and resolving forces. By the *composition* and *resolution of forces* we mean respectively the estimation of the net result, so to speak, of the action of a number of forces—and the discovery and identification of a number of forces of which only the net result can immediately be observed. A problem in the composition of forces, for instance, would be the determination of a future position of a planet at a given moment by means of our knowledge of the various forces that are acting upon it. A problem in the resolution of forces would be the discovery of the various forces that determine the actual observed motions of a planet.

So far, then, we may say that whilst the first law gave us a definition of force, the idea of inertia and the means of measuring time, the second law gives us the key to the composition and resolution of forces. It gives us the key also to the measurement of force and to the measurement of mass, and it also enables us to study the motion of a particle—that is to say, the ideal motion of a unit of matter.

A Falling Stone on a Moving Ship. Perhaps the simplest illustration of the first assertion of the second law of motion is the case of a stone dropped from the mast of a moving ship. As everyone knows, the stone will fall at the bottom of the mast, just as it would if the ship were not moving, yet during the time that the stone fell the ship may have advanced many feet upon her journey. The first law of motion teaches us that the falling stone must retain in falling the motion which it had when it was attached to the ship, and the second law teaches us that the external force of gravitation acts independently upon the whole, ship and stone together, with exactly the same result, whether both are moving or both are at rest.

Another illustration is furnished by a cricket ball. If to practise catching you run rapidly forward, throwing up the ball at intervals, you know, by experience, that it is not necessary to throw the ball forward, as you might at first expect; you throw the ball vertically upwards as you run, yet it comes down again into your hand, though your body has travelled a long distance forward in the interval. The curved course of the ball in its flight through the air is

deducible from the first and second laws of motion.

How Neptune was Discovered. A most conspicuous instance of the truth of these laws was furnished by the discovery of the planet Neptune, which was, of course, unknown to Newton. Newton had furnished the astronomers with the law of gravitation and with the laws of motion, yet when they came to study the actual observed movements of the planet Uranus (also unknown to Newton) they found that these movements did not tally with what the laws would have led them to predict. They assumed, however, the truth of these laws, and set to work to discover the nature of another force unknown to them which must be acting in order to cause the anomalous movements of the planet they were watching.

Two astromoners, one in Cambridge and one in Paris, each quite ignorant of the other's work or calculations, set themselves this task. Each independently declared that, if the laws of motion and gravitation were true, there must be, at a certain spot in the heavens, a certain mass of matter hitherto unknown to astronomers; the presence of such a mass of matter in such a place would account, they said, for the perturbations in the movements of Uranus, assuming the truth of the laws of motion. When the telescope was turned to the point indicated, the planet which we now call Neptune was discovered.

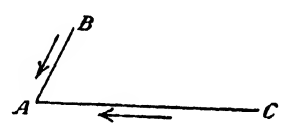
Measurement of Force and Mass. We have already stated the possibilities which are afforded us by the second law of motion, and we must make a further brief reference to them. It enables us, we have said, to measure force, for by this law a uniform force may be measured by observing the momentum which it produces in a given time. Thus the unit of force will be that force which produces a unit of acceleration when acting on unit mass. This may be expressed symbolically as $F = ma$. Similarly, it will be readily seen that we have also a means of measuring mass, since mass, force, and acceleration are now seen, in virtue of the second law of motion, to be quantities which have a constant connection with one another.

As we can measure a force by measuring the amount of acceleration which it imparts to a known mass, so we can also measure mass by estimating the acceleration imparted to it by a known force. It will be readily understood that the second law of motion is capable of almost indefinite discussions and illustration, because of the high complexity of the ideas which it contains. Here, therefore, we will merely discuss two points which it raises. And first as to the familiar theory of the *parallelogram of forces.*

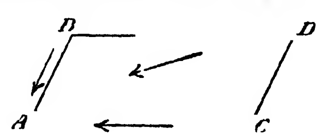
The Parallelogram of Forces. This phrase at first means nothing at all, for by a parallelogram we understand a figure or diagram on a piece of paper, whereas by a force we mean something which seems to have no relation to such a diagram. But when we speak of the parallelogram of forces, we assume—and it ought to be clear that we do assume—a symbolic way of representing forces. We find that forces and velocities and accelerations can all be perfectly represented by straight lines. Of a straight line it may be said that it has magnitude, inasmuch as it may be longer or shorter, and direction; and of these two ideas our ideas of force, acceleration, and velocity are compounded.

Hence we draw a straight line, making its length or magnitude to represent (1) in case of velocity the speed or rate of motion, (2) in the case of acceleration the number of units of velocity added per unit of time, and (3) in the case of force the magnitude of the force which, as we have already seen, is strictly proportional to the acceleration it imparts to any given mass; whilst the direction of the line indicates the direction of the motion which is implied in each case. Hence two straight lines, passing through a point, can give us a complete symbolic representation of two forces acting on any mass at that point, the length of each line being proportional to the acceleration which the symbolised force would impart to the mass, and its direction representing the direction of the force.

Now we find that from these two lines we may construct a parallelogram, if we represent the two forces by two lines which meet at the point in question. For instance, in the accompanying diagram, BA and CA represent two forces acting on a given mass at the point A—represent these forces both as to magnitude and direction.



Let us now complete the parallelogram, thus:



If now we draw the diagonal DA, it indicates exactly, both in magnitude and in direction, the resultant motion of the mass in virtue of the *composition* of the two forces BA and CA.

Similarly, we have the theories of the *parallelogram of velocities* and the *parallelogram of accelerations.*

We may state in technical language the theory which we have seen illustrated above by saying: *If two forces acting at a point be represented in magnitude and in direction by the sides of a parallelogram which meet in that point, the diagonal through that point represents the resulting force both in magnitude and in direction*

The Parallelogram in Practice. The simplest case and the most frequently illustrated of the parallelogram of forces is where the two forces are acting at right angles

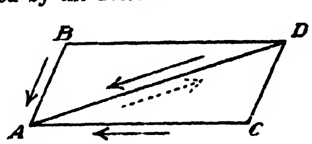
to one another. Everyone who has sailed a boat has a practical, if not a theoretical, acquaintance with the parallelogram of forces. Or take the case of a cross-Channel swimmer, whom the current is bearing in one direction, whilst his own muscles are bearing him at right angles to it. If the magnitude of the two forces, the force of the current and the force of his muscles, be represented by straight lines in the way we have seen, and then a parallelogram be constructed, the diagonal of that parallelogram will represent the actual course the swimmer's body will take.

The second topic raised by the second law of motion is most readily brought to the mind by the illustration of the various forms of lever. But before we can consider the lever, or, indeed, any of the problems of equilibrium, or of what is called *statics*—viz., the discussion of rest brought about by the balance of forces, we must devote some attention to the *third law of motion*, which is also involved.

The Third Law of Motion. This law may be said to assert that the mutual actions of any two bodies are always equal and oppositely directed, or that to every action there is an equal and opposite reaction. This exceedingly important law may be extended so as to have a much wider meaning, which Newton at any rate suspected. Thus we may say that the activity of an agent or the rate at which it does work is equal to the counter-activity of the resistance. We are here close to the proposition, which must later be discussed at length, of the *conservation of energy*.

Now let us consider again the general question of statics, that branch of dynamics which is concerned with the balance of forces. The chief problem of statics, we may say, is to discover the precise manner in which the combination of a number of forces acting on a body—each of which is in itself the cause of motion—shall produce not any kind of motion, but *equilibrium*, or *rest*.

Now, in the last diagram we saw that two forces, represented by the lines BA and CA, tended to produce a motion which can be represented both in magnitude and direction by the line DA; whence the proposition of the parallelogram of forces enables us to assert that equilibrium, or rest, will be attained if to the two forces BA and CA there is opposed a single force, to be represented in magnitude by the line DA and in direction by that line, save that it acts not from D to A, but from A to D, as indicated by the dotted arrow.



Hence the result of the interaction of three forces represented by BA, CA, and AD will be rest. This is perhaps as simple a problem in statics as we can name.

The Triangle of Forces. Now we may go further and show that, since BD is equal to AC, the fact of rest, or equilibrium, may be represented in our diagram by a closed figure—in this case a triangle, AB, BD, DA. This is what is known as the *triangle of forces*, and it is capable of great extension. It can be proved that if any number of forces acting at a point can be represented in magnitude and in direction by the sides of a closed figure taken in order, the net result of the action of all these forces will be rest—or, in other words, these forces will be in equilibrium. The triangle of forces is thus a special case of the *polygon of forces*, a polygon here being taken to mean any closed figure bounded by a number of straight lines—literally, it means many angles.

If only two forces act on a body, it is evident that rest or equilibrium will result only when the two forces act at one point, when they are equal in magnitude and opposite in direction. If the forces are not acting at one point, a new problem arises—viz., the problem of a motion of a system of particles as compared with the much simpler problem of the motion of a single particle.

What we mean by Equilibrium. By equilibrium we mean that state of balance among the forces or sets of forces acting on a body in virtue of which there is no resulting tendency for the body to change its state, *whether of rest or of motion*. Statics is precisely the study of forces in such equilibrium.

The first point to note is that we must not confuse equilibrium with rest. Whenever there is rest there is certainly equilibrium. A book lying on the table is at rest, because there is equilibrium amongst the forces which tend to pull it towards the earth and the forces by which it is sustained, but this is only one kind of equilibrium or stability. We may call it *static stability*, meaning that the body is stable, in a state of rest. But, on the other hand there may as certainly be equilibrium or stability where there is motion. This we call a moving equilibrium, or a case of *kinetic stability*. Whenever a body or a system of bodies tends to remain or be stable in a steady state of motion, we have an instance of a moving equilibrium, or kinetic stability; hence equilibrium does not necessarily mean rest, but is compatible with steady motion.

A vehicle drawn along at constant speed, in virtue of the continued action of the forces that tend to drag it on and the forces that tend to hold it back, the resultant of the two sets of forces being constant, as is proved by the constant motion of the vehicle, is as truly in a state of equilibrium or kinetic stability as it is when it comes to rest.

For many decades of the nineteenth century it was believed that the solar system is an instance of a moving equilibrium—furnishes a case of kinetic stability; but it is now known that other internal forces besides those recognised by the great French mathematicians who were contemporary with Napoleon are at work in the solar system, and that, therefore, it does not furnish a case of kinetic stability.

To be continued

Continued from page 461

THE OCEANS OF THE WORLD

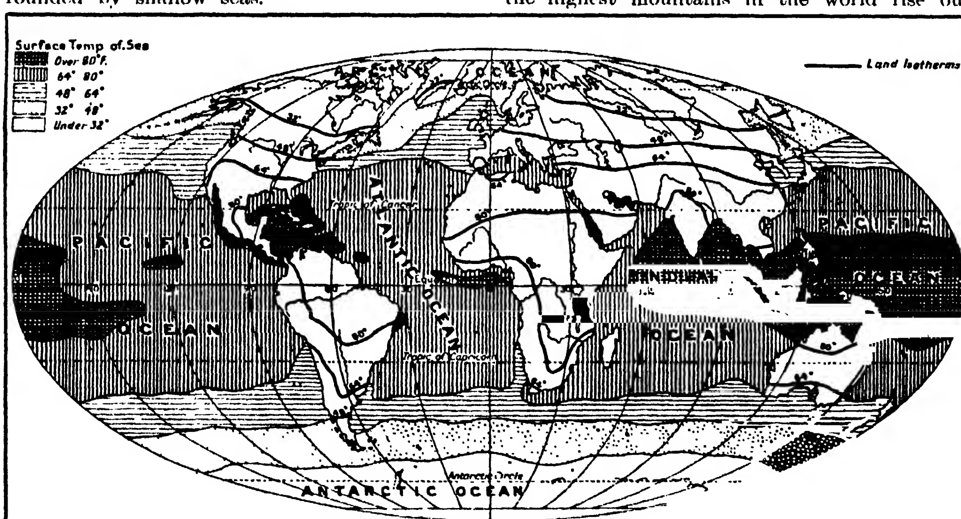
The Water Cycle. The Rivers and the Sea. Chemistry of Sea Water. Tides and their Movements. Currents. Coral Islands

By Dr. A. J. HERBERTSON and F. D. HERBERTSON, B.A.

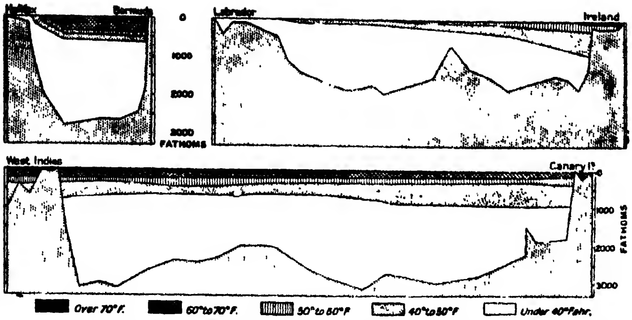
Deep and Shallow Seas. The seas over the continental shelf are everywhere shallow. The continental shelf is very broad in the northern part of the Pacific, where, if the sea sank 600 ft., North America would be joined to Asia by an isthmus over 1,000 miles wide. A broad continental shelf, covered by shallow seas, extends along the Atlantic shores of the New World. The broad continental shelf of North-west Europe is covered by the shallow North Sea, leading to the shallow Baltic Sea. A broad continental shelf, on which lie the East Indies, borders the Pacific shores of Asia. A similar broadening of the continental shelf connects Australia with New Guinea on the north and Tasmania on the south. All these lands are immediately surrounded by shallow seas.

40. THE CIRCULATION OF WATER
The arrows show the water rising in the form of invisible vapour from the sea, then, passing into cloud, it forms and descends as rain on the mountain tops, being thence carried by the river to the sea

Beyond the continental shelf the ocean varies greatly in depth. Its greatest depths, as we have seen, may be compared roughly with the greatest elevation of the lithosphere. The principal deeps are found along both margins of the Pacific. The deepest are the Japan, or Tuscarora Deeps, off the north-east of Japan; the Marianne Deeps (the deepest in the world, over 13,500 ft.), off the Marianne Islands, between Japan and New Guinea; and the Kermadec (over 30,000 ft.) and Tonga Deeps, off islands of the same name lying to the north-east of New Zealand. These are all on the eastern margin of the Pacific. On the western margin great depths occur off the Aleutian Islands of North America, and off the coast of Chile, where almost the highest mountains in the world rise out



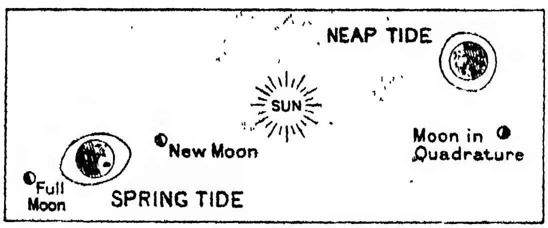
41. TEMPERATURE OF THE OCEAN
The warmer the water, the deeper the tint



42. SECTIONS OF THE NORTH ATLANTIC OCEAN SHOWING TEMPERATURE AT DIFFERENT DEPTHS
The darker the tint the warmer the water

of almost the deepest seas. In the Atlantic the greatest depths are north of Porto Rico (28,000 ft.). On the eastern margin of the Indian Ocean is the Sunda, or Java Deep, off Java (under 20,000 ft.).

The oceans receive the waters of innumerable rivers. This constant gain, however, is counterbalanced by the loss due to evaporation, which goes on all over the surface of the ocean, with an intensity varying with the atmospheric conditions [40]. We have already investigated the process in our examination of rain. The moisture absorbed by the atmosphere takes part in the great rhythm of water circulation already described, and, falling at last as rain, is ultimately restored by rivers to the ocean, to start once more on its cycle of change.



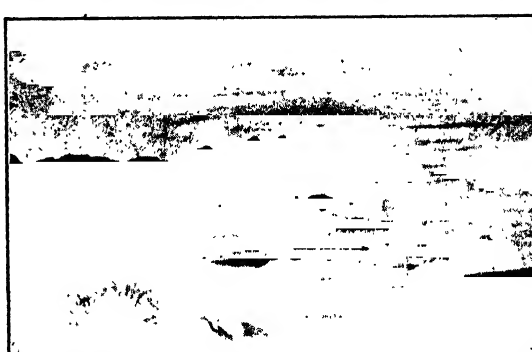
43. HIGHEST AND LOWEST TIDES

The Chemistry of Sea Water. Rivers, in passing over the surface of the land, become more or less heavily charged with chemical substances, which they carry into the ocean. These are left behind in evaporation, and their presence renders the ocean brackish. Of chemical substances present in the ocean the most abundant is common salt, which, if spread out over the land, would form a layer many feet thick. Only a small part of this is brought down by rivers. The origin of the rest is an unsolved problem. Sea water, being thus heavily charged with chemical matter in solution, is heavier than fresh, and one can, therefore, float in it more easily, as every bather knows.

The salinity of sea water varies in different parts of the world and at different depths. The surface waters are saltest where evaporation is most rapid, and rainfall least—that is, in the dry parts of the hot belts. The cold Polar waters, where evaporation is slowest, are least salt on the surface. Inland seas, like the Mediterranean and Red Seas, which receive few rivers, are exceedingly salt.

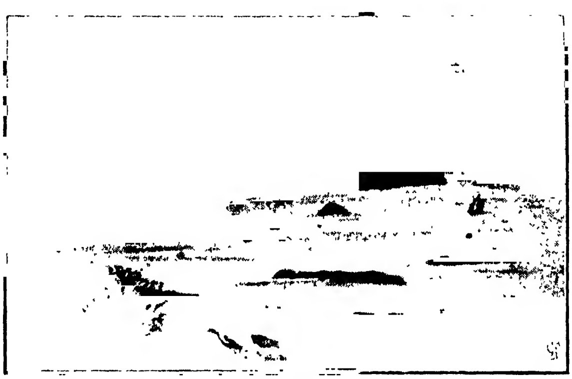
Temperature of the Ocean. A great part of the sun's rays are reflected back from the surface of the ocean, causing the glare so familiar to those who look at the sunlit sea. The rays which are not reflected off heat the upper layers, which become heavier through evaporation and consequently sink, heating the layers below by the movement of their heated particles. This heating action, though it penetrates much deeper than in the case of land, reaches to no great depth. In the hot zone the surface temperature of the ocean is about 70° F. [47], but half a mile below the surface it is only 38° F., or but a few degrees above freezing point [41]. Enclosed seas like the Mediterranean and Red Seas, lying wholly in warm latitudes, have a much higher temperature. The surface temperature of the Red Sea and the Persian Gulf may be as high as 90° F. The great oceans, which extend through all the climatic zones, have a great range of surface temperature [42]. In the Polar oceans the surface temperature is about 38° F., which may probably be taken as the average temperature of the ocean.

How the Moon Attracts the Sea. The tides are periodical risings and fallings of



44. EFFECT OF THE SUN ON TIDES
Spring tide. Low water about 6 p.m.

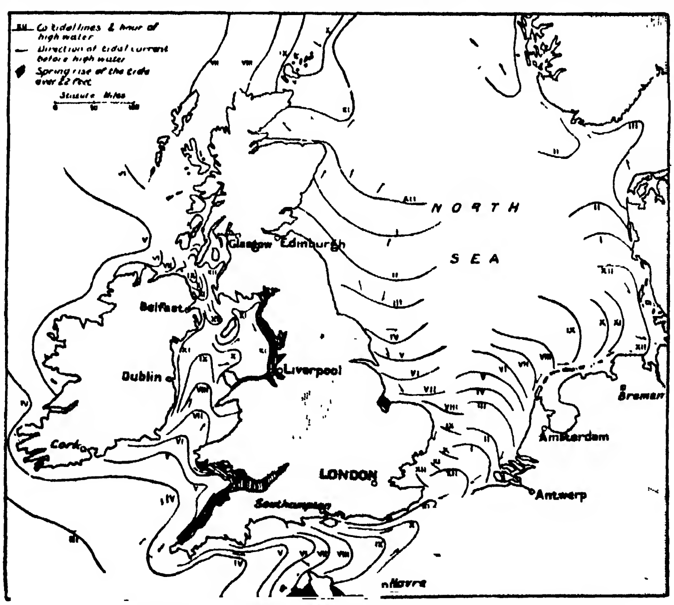
the waters of the ocean which take place twice daily. Students who are not familiar with advanced mathematics must be content to accept the statement that they are caused by the attraction of the moon, which is distant less than a quarter-million miles. The moon's attraction acts on sea and land alike, along the line passing through the centres of both earth and moon. Along this line both water and land are, as it were, pulled towards the moon, causing a heaping up of water on the side of the earth nearest to the moon, and a similar heaping up of water on the side furthest from the moon owing to the land being pulled towards the moon. These facts, which really belong to the study of astronomy, physics, and mathematics [which see], cannot well be more simply stated than in this form. The student who does not thoroughly understand them will do so as he advances in the course of ASTRONOMY. All that the student of geography needs to bear in mind is that the moon's attraction does, in the manner roughly described, gather the waters of the earth into a double wave, with one crest on the side nearest to the moon, and the other crest on the opposite side [43]. As the earth rotates, this double wave moves round the earth, retaining its relation to the moon and the crests and troughs alternately producing high and low tide. Thus there are two high and two low tides daily, at intervals of rather more than twelve hours, or half a lunar day.



45. SPRING TIDE. HIGH WATER AT MIDNIGHT
Spring tides always occur at full or new moon

The Meeting of the Tides. The attraction of the sun similarly tends to cause tides, but in a much less degree, owing to its enormous distance [44]. When the sun and the moon act in the same line, which happens at new and full moon [See ASTRONOMY], the highest, or spring tides occur. The lowest, or neap tides, are when sun and moon attract in different directions and partially neutralise each other [45]. This happens when the moon is one quarter or three-quarters full.

Owing to the different distribution of sea and land, and the varying relief and depth of the sea bottom, which causes different degrees of friction in different parts of the ocean, the tides on different shores are by no means uniform. As the ocean becomes shallower towards the shore the waters become heaped up, often forming tides of great height. This is particularly the case when the tidal wave is forced up an estuary or other narrow opening. The incoming tide then advances like a wall of water. Such high tides, or bores, are seen on a huge scale in the Bay of Fundy in Nova Scotia, and in Hangchou Bay in China. On a smaller scale they occur in the Severn, where the tide rises 40 or 50 ft. at Bristol, in the Seine, and other European rivers.

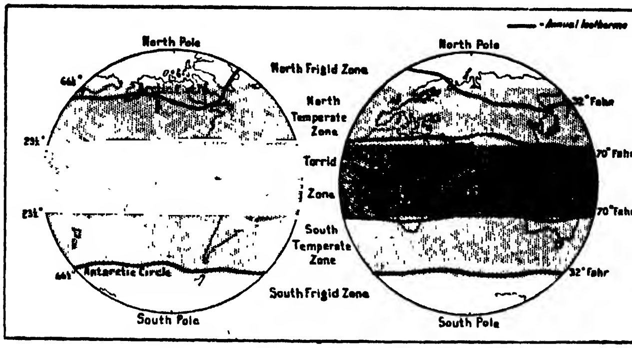


46. PROGRESS OF THE TIDES ROUND THE BRITISH COASTS

Where the tide enters an enclosed sea various modifications occur. Thus the Atlantic tides enter the North Sea both round the south of England, through the Strait of Dover, and round the north of Scotland [46]. The crests of two tidal waves meet at the Thames estuary, causing very

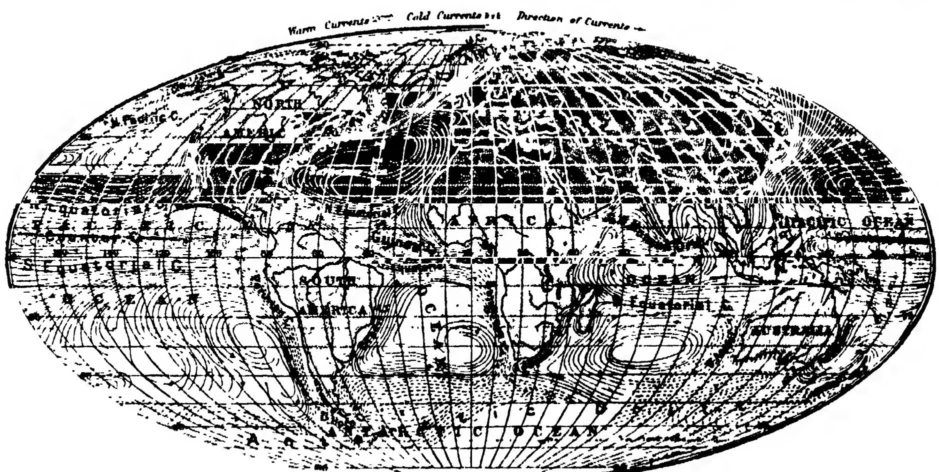
high tides, which add greatly to the advantages of London as a port. On the opposite side of the North Sea there are places where the trough of one tide neutralises the crest of the other, causing no tide to be felt. In the Mediterranean, which is practically landlocked, the tidal wave is stopped by a sort of natural breakwater, and practically no tide is felt beyond the Strait of Gibraltar.

For the student of geography tides are mainly important for their influence on commerce, which will be considered when we reach the commercial side of geography.



47. THE ZONES

Surface of the Ocean. The surface currents of the ocean are caused by the prevailing winds which have already been described. These tend to pile up the waters on the lee side of the ocean and to suck up water from lower depths on the windward side. Thus the windward side is cooled by the rising of the cooler lower waters to the surface and the leeward side is warmed by the inflowing of the surface waters, except where the set of the surface currents is towards the Equator. Currents, being caused by winds, share in the seasonal variations already noticed.



48. OCEAN CURRENTS

In every ocean the surface waters are impelled slowly in great eddies, moving, in the northern hemisphere, with the hands of a watch, and in the southern hemisphere in the reverse direction. The centre of the eddies lies in mid ocean, about lat. 30°—that is, in the high pressure area formed in the horse-latitudes. On the equatorial side of these eddies the currents move west, driven by the trade winds; on the Polar side they move east, driven by the westerly winds; while on the east side they are drawn towards the Equator, and on the western side towards the Pole, in the circling eddy already mentioned [48]. In the southern hemisphere, where there is a vast continuous belt of unbroken ocean, the east-flowing currents unite to form a circum-polar eddy. Round the Equator the distribution of sea and land prevents the development of a similar circum-equatorial eddy, encircling the world, and breaks it up into the separate eddies just referred to.

The Atlantic Currents. The Atlantic is S-shaped, and this causes surface water from the southern hemisphere to be forced westwards towards the north-east coast of Brazil, where it divides, the northern branch passing into the northern hemisphere along the Guianan coast, both inside and outside the American Mediterranean. This current is, of course, a warm one. Further north that branch which passes outside the West Indies is reinforced by a warm current from the Gulf of Mexico, and the united current, known as the Gulf Stream, moves first as a perceptible surface

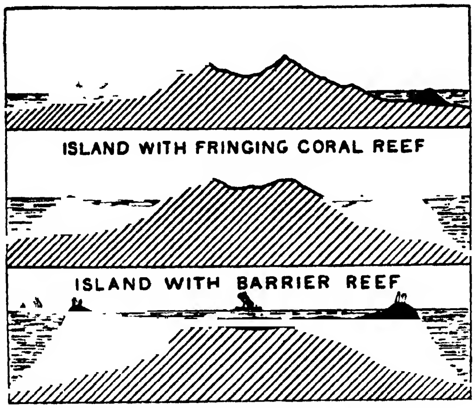
stream of warmer water, which gradually becomes less and less marked, after which it is called the North Atlantic or Gulf Stream Drift When this current reaches the latitudes of the westerly winds it is carried east towards the Old World, where it flows out partly to the south-east, forming the Canary current, and partly to the north-east by the wide passage between Greenland and Europe. This warm drift serves to keep the ports of Western Europe ice-free in winter even in the north of Norway.

There are two cold currents from the Arctic, by Davis Strait and East Greenland, the former reinforced by upwelling water, forming what is called the *cold wall*, off the United States coast.

Pacific and Indian Ocean. In the Pacific Ocean similar currents are modified by the circular configuration of that ocean. There is no great transference of warm water from the southern hemisphere north across the equator, and no great north-east current penetrating to high latitudes. The warm north and north-east current, known as the Kuro Siwo in Japanese waters, is similar to the Gulf Stream, but the almost unbroken barrier of land to the north prevents it from penetrating to Arctic waters. The northern part of the current turns north and north-west, off the coast of British Columbia, and keeps the north-east ports of the Pacific ice-free.

In the Indian Ocean the land is continuous north of the tropic of Cancer, and the winds blow inwards as monsoons in summer and outwards in winter. India juts out and breaks the ocean into two divisions, in both of which the waters circle clockwise in summer and in the reverse direction in winter.

Where winds blow steadily off the land they carry the surface waters before them, and these are generally replaced by colder water from below. Such cold upwellings occur off the West Coast of Africa and in similar latitudes in the Pacific.

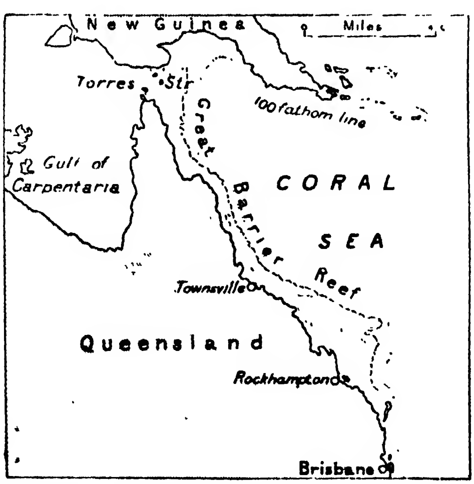


49. CORAL ISLANDS

Where an inland sea like the Mediterranean or Red Sea is hot, and subject to great evaporation without many rivers to replace it, a surface current flows into it from the ocean. Inland seas, like the Baltic and Black Seas, which receive many rivers, may have a surface current outwards [48]. New land is formed beneath the ocean by the accumulation of sediment brought down by rivers, and is gradually pressed into a hard, solid form by the weight of the upper layers. The rate of formation is most rapid near the shore, but may continue hundreds of miles out to sea, according to the size of the rivers and the set of the currents. By a similar process the limy skeletons of minute sea creatures gradually form the rock we call chalk. [See page 7.] The chalk districts of Britain must in some distant age have been beneath the level of the sea.

Coral Islands. Coral islands are found almost exclusively in the tropics. The living coral polyp is a beautiful creature, the soft, fleshy, living parts of which resemble minute flowers.

Coral formations are of two kinds, *reefs* and *atolls* [49] The former may be either *fringing reefs*, occurring in the shallow seas close to land, or *barrier reefs*. Barrier reefs occur at a distance from the shore, where there is a channel of shallow water. They surround many islands in the Pacific, and are often broken by gaps opposite the mouths of rivers. The finest example is the Great Barrier Reef, which stretches for 1,200 miles along the north-eastern coast of Australia, at a distance of from 20 to 100 miles from coast [50]. Atolls are circular reefs, often rising from great depths. Inside the reefs are lagoons of transparent green water, fringed with white coral rock and sand. The coral polyp dies at sea-level. All purely coral islands, therefore, are low. The waves break off and heap up blocks of coral, which are gradually reduced to brilliant white sand, forming an island on which wind-transported seeds take root



50. THE GREAT BARRIER REEF OF AUSTRALIA

To be continued

Group 10 **ELECTRICITY** 4 Continued from page 467	# ELECTROMAGNETISM. **Forces with which Magnets Pull. Magnetic Curves. Typical Forms of Electromagnets. Lifting Magnets used in the Workshop**

By Professor SILVANUS P. THOMPSON

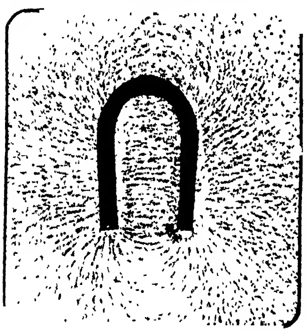
Properties of the Magnet. Every schoolboy knows that a magnet will pick up a bit of iron and stick to it, and that it will not attract silver, gold, copper, tin, lead, or such substances as glass, wood, stone, porcelain, paper, nor any animal or vegetable products. Every schoolboy also knows that a magnet, or a magnetised piece of steel will, if poised or hung so that it can turn, point towards the north. Anything that possesses these two properties is a *magnet.*

It is found that magnets can be made either of lodestone—a hard, black oxide of iron found in Sweden, Arkansas, and Spain—or of some kind of hard iron or steel. They can also be made of the metals cobalt and nickel, which resemble iron. No other metals are magnetic to any appreciable degree. The magnetism of magnets is found apparently to exist chiefly at the ends, or *poles* ; the other parts of the magnet show scarcely any magnetic property on the surface. The oldest magnets were natural lodestones. To magnetise pieces of steel, it suffices to rub them upon the pole of a powerful magnet. If the steel is hard, it will retain a good proportion of the magnetism so imparted to it. If the steel or iron be soft, it will retain little or none, particularly if the piece be short in shape.

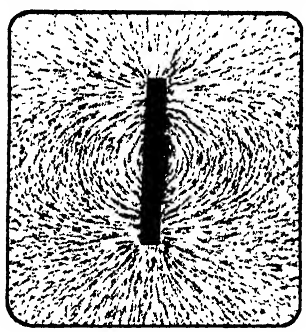
Those who want further information on the simple properties of magnets or of the magnetic compass should refer to the articles thereon in PHYSICS. We can here deal only with a few points that lead towards the industrial applications.

Experiments with Magnets. Procure a small horseshoe-shaped steel magnet, also a bar magnet, and a few bits of iron—as, for example, nails. Procure also some clean iron filings. The iron filings may be oily and dirty as they come from the workshop bench. They can be cleaned by stirring them well about in hot soapy water, and afterwards washing in clean water, after which they should be drained dry on a cloth or on blotting-paper. They should also be sifted through a pepper-box or a piece of coarse muslin, the finest filings only being kept for use.

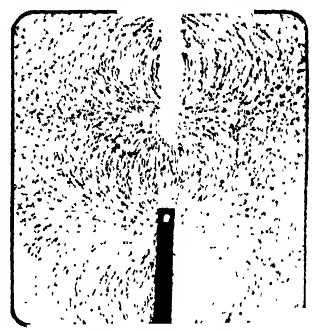
If a magnet be plunged into iron filings they are found to adhere in tufts. These tufts are chiefly on the ends, or polar regions, of the magnet. If a tuft be examined, it is found that each hair in the tuft consists of a lot of filings which have arranged themselves as in a chain, and adhere together, the end of one filing to the end of the next. If the tuft be pulled off the magnet it falls at once to dust again. Put the magnet with its pole or poles upwards, under a card or under a china plate, and put a few filings on the plate. The filings will stand up in tufts over the place where the magnet is, and if the magnet be moved the tufts of filings will follow it.



16. CURVES OF HORSESHOE MAGNET



17. CURVES OF BAR MAGNET



18. CURVES BETWEEN TWO POLES

Another experiment is to hang a nail to the pole of a magnet, then to hang a second nail to the bottom end of the first, and a third nail to the second, and so on, so that they hang in a chain. Each bit of iron, in fact, becomes a magnet while it is under the influence of the larger magnet, and will adhere to other bits of iron.

Filing Figures—Magnetic Curves. As the attractive force of a magnet is exerted more by some parts of it than by others, we shall explore the distribution of these forces by the aid of iron filings. The chains or filaments into which the filings gather themselves under the influence of the magnet tend to take definite directions. But when these chains, or filaments, hang from the pole of a magnet or stand upon its surface, their own weight

prevents them from assuming their full development. To observe them properly, arrangements must be made to relieve them of their weight. This is done very simply, by laying the magnet down upon a table, then laying over it a flat, thin sheet of cardboard, or a sheet of thin glass, upon whi h the iron filings are sprinkled as uniformly as possible, using as a sprinkler a pepper-box or a bottle with gauze over the mouth.

When a thin sprinkling of filings has thus been obtained, the sheet of card or glass should be gently tapped at the corner with a pencil or with the finger, when the filings will be seen to rearrange themselves in beautiful patterns or figures, thus exhibiting to the eye the forms of the magnetic curves. Fig. 16 gives, in photographic reproduction, the curves of a horseshoe magnet, and 17 those of a bar magnet.

Causes of Magnetic Curves. Now, the real point of interest of these filing figures is that they map out visibly to the eye the paths of forces that would otherwise be invisible; and the mechanical forces which magnet-poles exert on one another are actually exhibited and depicted by these magnetic curves. This relation will be better understood if we take a case in which the mechanical relations are already known. It is one of the oldest known facts about magnets that if the north pole—by which we mean the pole that points northwards if the magnet is hung up, or floated, free to turn—of one magnet be placed near to the south pole of another magnet, they tend to run together mechanically, as if they attracted one another.

In reality, as we shall better understand hereafter, they are pulled or urged towards one another by something that is going on in the space in between, and the older writers, who did not know about this intervening action in space, thought that they attracted one another. To investigate the action, lay down two bar magnets on the table with the north pole of one near the south pole of the other, as in 18, interposing, if need be, a small bit of wood to keep them from running together. Then place over them a sheet of card and observe the filing figure. It will resemble that shown in 18, in which we see that the magnetic curves form a series of arching lines which start from the surface of one magnet and run across the space to the surface of the other.

Magnetic Lines—Magnetic Field. The interpretation of these lines is that wherever we find them crossing any part of space there is a mechanical tension of pull exerted across that space, the direction of the tension being along the lines. In fact, the mechanical forces are such as would be exerted if the magnetic lines of the pattern could be regarded as threads of some stretched elastic substance, tending to shorten themselves. In reality, these filing curves map out stresses in the intervening medium. These stresses really exist in the neighbourhood of the pole of a magnet, but we cannot *see* them until their existence is revealed thus by the sprinkled filings.

Now, these stresses in the medium that occupies the space between magnet poles exist, whether we sprinkle filings about in order to explore them or whether we do not. We must therefore conceive of the space in any magnetic region near or between the poles of a magnet as being always full of invisible magnetic lines, which run in the directions of the forces, and of which the chains of filings are a crude representation.

We can explore these lines in several other ways, one of which is to take a small compass-needle and place it in the part of space we wish to explore, when it will at once turn and point along the direction of the magnetic lines, setting itself, in fact, at a tangent to the magnetic curve that passes invisibly through its centre. Any region of space across which in this way the magnetic lines are invisibly passing is called a *magnetic field*. Near the pole, or between the poles, of powerful magnets, where the magnetic forces are strong, the field is described as being very *intense*, the lines being numerous and close together. The whole number of lines that proceed out of any magnet pole is called *the magnetic flux* from that pole.

Flux-densities. The lines really come up through the metal, passing right through the magnet itself. The region or part of the surface where magnetic lines emerge from the magnet into the air is called its north pole. From this pole they spread out in diverging or radiating directions, then arch round in curves and re-enter the magnet at the other region, which is called the south pole. Where the lines are very close together, and the magnetic tension along them is strong, the flux is said to be *dense*. The term *flux-density* is used to denote the number of lines per unit of area crossing any surface placed squarely across their path. It is, for example, quite common in dynamo-electric machines to find in the gap that lies between the magnet poles and the adjacent surface of the armature a flux-density of 50,000 lines per square inch. For the definition of the magnetic line the reader must refer to the article on magnetism in PHYSICS, or to some book on magnetic units.

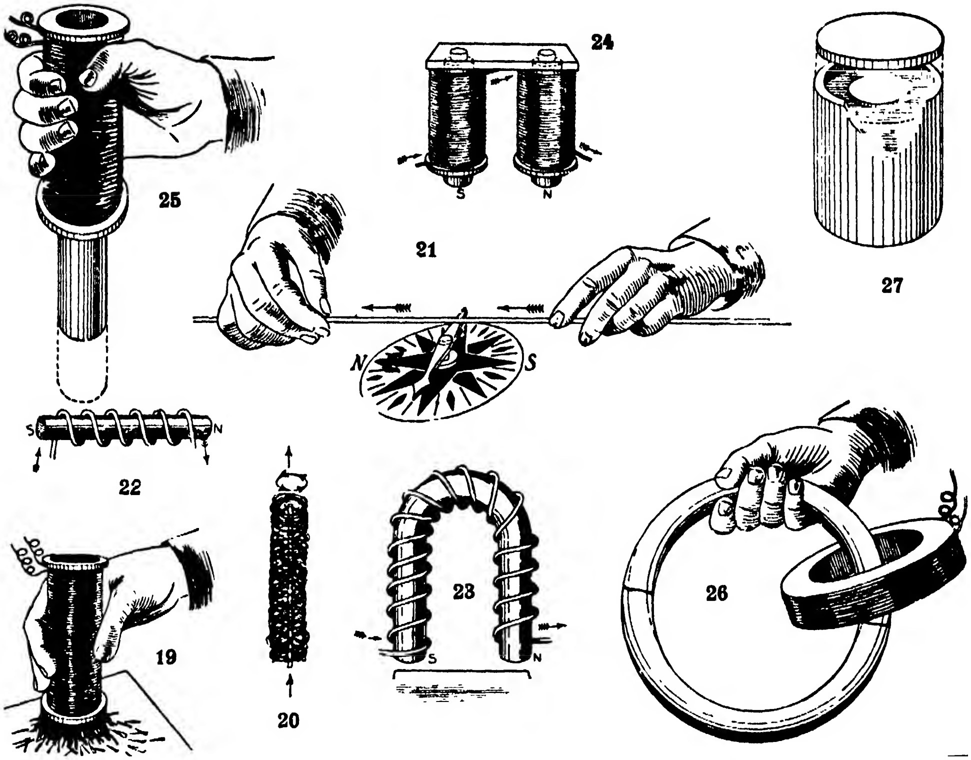
As the magnetic lines run through the bodies of magnets and masses of iron more readily than through air, it follows that in magnet cores we often find very high flux-densities. In fact, cast iron can readily be magnetised up to a flux-density of about 45,000 lines to the square inch, while soft wrought iron and mild steel can easily be magnetised up to a flux-density of 100,000 lines to the square inch. The symbol **B** is in general use to denote a flux-density—that is, the number of lines per unit of area.

Magnetic Pull and Flux-density. The mutual pull between two flat magnet poles is related to the flux-density in the space between them, and depends also on their area. It is found by experiment that if different flux-densities are tried, the pull increases as the square of the flux-density. Suppose that in any given case there is a small flux-density, and a small pull, then, if we can get double the flux-density, the pull will be found to have increased fourfold; and if we treble the flux-density, the pull will have increased ninefold. In fact, the pull

between two flat magnet poles that are near together can be calculated by the formula:

$$P = B^2 \times A \div 72{,}134{,}000,$$

where P is the pull in pounds' weight, B the flux-density in lines per square inch, and A the area of surface of each of the flat poles in square inches. For example, if we have two magnets, each of which has a pole of area 2 sq. in., and if the flux-density between them be 25,000 lines per square inch, the pull which they exert on one another will be $25{,}000 \times 25{,}000 \times 2 \div 72{,}134{,}000$; or, working out the sum, we find it will be 17·3 lb. The difficulty in using such calculations is to find out how much B is going to be.



DIFFERENT FORMS OF ELECTROMAGNETS AND THEIR ACTION

19. Coil attracting Iron Nails
20. Magnetic Whirl around Wire Carrying Current
21. Current in Wire Deflects Compass-needle
22. Sturgeon's Bar Electro-magnet
23. Sturgeon's Horseshoe Electro-magnet
24. Modern Two-Pole Electromagnet
25. Iron Core sucked up by Coil
26. Magnetisation of Iron Ring
27. Jacketed Electromagnet

Magnetic Action of an Electric Current. All the preceding paragraphs of this article have been about magnetism only. Not one word has been said about electricity or electric currents. If electricity had never been discovered, all that precedes about the properties of magnets and magnetic lines would still be true, for magnetism was discovered centuries before the electric current was known. And yet, as we must now learn, electric currents can be made to act as magnets.

For this purpose we must construct a special coil of wire. Suppose we procure 100 ft. of copper wire, of the size known as No. 18 standard wire-gauge. It must not be bare wire, but insulated by being overspun with cotton, to prevent the spires of the coil from coming into contact, and the weight of it will be about 1 lb.

Let us prepare, as a core on which to wind it, a wooden, rod-like, small, round ruler, ½ in. in diameter, and a little over 4 in. long. We shall need two discs, or cheeks, to be fastened on, so as to leave 4 in. length of winding space. A bit of brass tube with brass cheeks soldered on 4 in. apart will do even better, but if metal is thus used the winding space should be lined with paper before beginning the winding.

If we wind this wire on such a prepared bobbin, we shall find that we shall get about 65 turns of wire in the first layer, and if we go on winding layers, there will be length enough of the wire for about six layers. The ends must be secured from unwrapping, and cleaned up so that they can be connected to a suitable battery.

Now, such a coil of copper wire has of itself no magnetic properties at all. If we try it, it will not pick up a single iron nail, nor act on a compass-needle. But if we connect its ends to a battery so that a current flows along the wire,

and goes therefore circulating round and round the core, we shall find, if we try it while the current is on, that it is quite a powerful magnet, and will pick up nails or tinned tacks, as depicted in 19. Directly, however, that we break the circuit and stop the current from circulating, the coil will cease to act as a magnet.

Electricity in Circulation. This experiment has taught us a new fact—*electricity in circulation is magnetism.* For here, without having any steel, iron, or lodestone, we have got a magnet that will attract bits of iron, and by a little experimenting we can easily prove that the coil has two poles, one at each end, and that one end is a north pole, which will attract the south pole of a compass, while the other is a south pole, which will attract the north pole of a compass. The coil is of copper wire. But it is not the copper that does the attracting; it is the electric current in the coil, for the attraction stops when the current stops. And if we had made our coil of silver or gold wire instead of copper it would have worked just as well.

Before we go on, let us give a thought to the amount of circulation of current in the coil. If we have used only one cell to generate current we shall have had but a weak current—perhaps less than half an ampere. If we have used one good Fuller's cell, we shall probably have had at least 1½ amperes. If we use a battery of half a dozen Fuller's cells in series, we shall have a bigger current, perhaps 6 or 7 amperes. Of course, if we want to ascertain how much current our battery is sending through the coil we must use a proper *amperemeter*. [See How to Generate a Current, p. 291.]

The stronger the current the more powerful will the magnetism of the coil be. Now examine the coil to see how many turns of wire there are on it. If there are 6 layers of 65 turns per layer, the total number of turns will be 390. Therefore, the current, whether weak or strong, has to go 390 times round the core before it leaves the coil. Suppose we had been able to get a current of 7 amperes from our battery. Then, 7 amperes going 390 times round will produce exactly the same magnetic effect as 1 ampere going 2,730 times round, or, in electricians' language, producing a circulation of 2,730 *ampere-turns*. One ampere-turn means 1 ampere going round once. To ascertain the number of ampere-turns in any magnetising coil we have to count the number of turns, and observe the number of amperes, and then multiply the two numbers together.

Magnetic Field of a Current. We shall naturally inquire whether or a single turn of an electric circuit has any magnetic properties, or whether a straight wire along which a current is being conducted will act magnetically. A straight wire will act in this manner. If a strong current is sent along a piece of bare copper wire, and the wire is laid down upon iron filings, it is found that some of them will adhere to the wire, not end-wise in tufts as they do to a magnet pole, but sideways, clinging on tangentially. And if a compass-needle is brought near a vertical wire that carries a current, it is acted on.

This action is, however, neither an attraction nor a repulsion, for the needle always tries to set itself square to the wire, pointing neither to it, nor from it, nor yet along it, but presenting its flank to the wire. The wire carrying a current is, in fact, surrounded by a magnetic fluid of its own, a field in which the lines are concentric circles around the wire, somewhat as in 20, constituting a sort of invisible magnetic whirl surrounding the current. If a current be carried, either in one wire or in a number of wires constituting an open coil, over or under a compass-needle, the needle at once turns to point across the direction of the wires. If a current runs from south to north over the compass-needle, the needle is deflected, as in 21, to the west. If it runs from north to south over the needle, the needle is deflected to the east. This deflection of a compass-needle by the current in a neighbouring conductor is the earliest discovery in electromagnetism, having been made in 1820 by Oersted. It is the fundamental principle of the *galvanometer*.

The Electromagnet. It was in 1825 that the most important departure was made in the invention of the electromagnet by William Sturgeon. Arago had, indeed, investigated the magnetic action of coils or spirals of wire when traversed by a current, and had found that he could magnetise steel compass-needles by inserting them into the inside of the coil, and then pulling them out again. But it was left to William Sturgeon to show that if a coil of insulated copper wire be wound upon a rod of soft iron, the combination acts as a powerful magnet when an electric current is sent through the coil.

This new kind of magnet differed from the older permanent magnets of steel, and from lodestones, in the following most important respects. First, it was more powerful relatively to its size. Secondly, its magnetism was under control, for it became a magnet only when the current was turned on, and ceased to be a magnet—and therefore dropped its load—as soon as the current was turned off. Thirdly, it could be controlled from a distance, for the switch or key by which, when required, the circuit was made or broken, might be anywhere in the circuit—might be at a distance of many feet, or even miles, away from the magnet itself. Figs. 22 and 23 are pictures of simple electromagnets such as Sturgeon produced.

Forms of Electromagnets. Some electromagnets are straight bars, and others are bent into horseshoe form like 23. A more common form—the form largely used in electric bells—is that shown in 24, in which the "horseshoe" is made of two short iron rods, or *cores*, fitted into a crosspiece of iron called the *yoke*. The advantage of this shape is that the coil can be separately wound upon two wooden bobbins, in a winding lathe, and these bobbins are then slipped upon the cores, and the wires joined up to make electrically one continuous coil.

We have suggested above experiments with a coil 4 in. long, wound on a brass tube or a wooden rod. The brass tube is preferable, because we can now introduce inside the brass tube a rod of iron projecting out at both ends,

when it will be found, on turning on the current to circulate around the coil, that the iron rod becomes a very powerful magnet. In fact, the electromagnet thus made by the iron core surrounded by the copper-wire coil will be immensely more powerful as a magnet than the copper-wire coil was without the iron core.

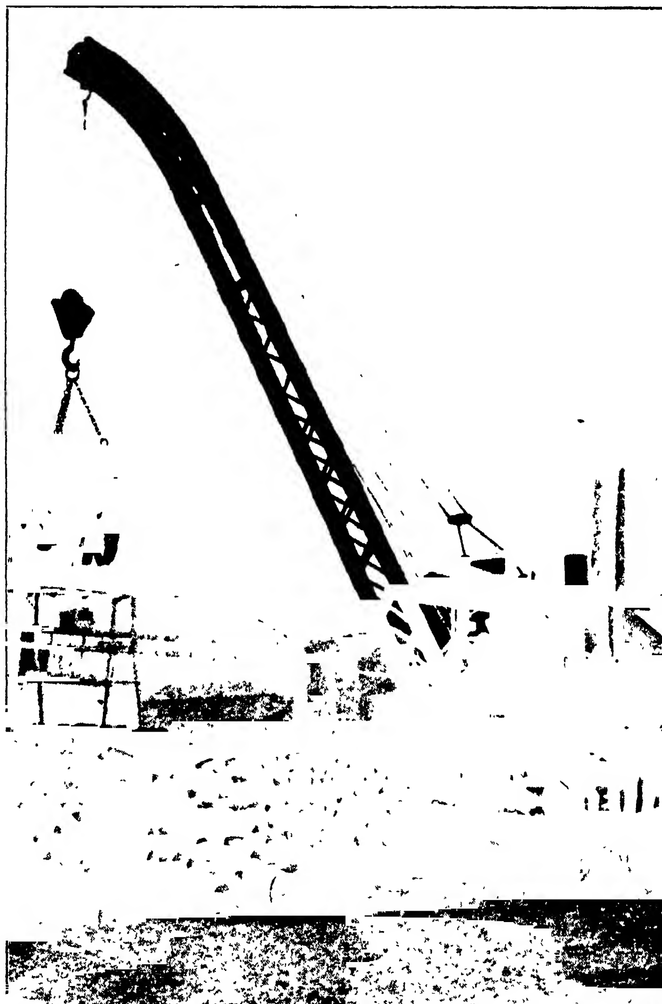
If in this form of apparatus the iron core is small enough to slip freely into the inside of the coil, it will be observed that, if the current is turned on at a moment when the iron core is inserted partly into the coil, the coil will suck the iron core into the interior. If the coil is fixed vertically, as in **25**, over a table, and the iron core is made to stand on the table, with its upper end within the mouth of the coil, then on turning on the current the iron core will be drawn up. On switching off the current, the core falls down again.

Experiment with an Iron Ring. For this experiment is required a ring, such as any blacksmith can forge, of soft iron—the softer the better—about 10 in. in diameter. It should be cut into two equal halves, and the ends faced off flat. There is also needed a coil of insulated copper wire, which should consist of a large number of turns, tied with string to hold them together, or coiled together, the coil being, say, 5 or 6 in. in diameter.

Let the two halves of the ring be put together, as in **26**, so that the iron ring is interlinked with the copper-wire coil, and let the current from a battery be now sent around the coil. This current, because it circulates around the iron, will magnetise it, and the two halves of the ring will attract one another with enormous force. In fact, if the iron has a cross section of as much as 1 sq. in. only, and the coil carries a decently strong current, it will be practically impossible for two people to pull the two halves of the ring apart. But if the current is turned off, at once the lower part of the iron ring will drop off.

Tractive Force of Electromagnets. The pull of an electromagnet upon a flat piece of iron in contact with its polar surface can be calculated by the formula given above, and as the flux-density at the polar contact surface of a soft iron pole can easily be raised to the value $B = 100{,}000$ lines per square inch, it follows by calculation from the formula that the tractive force of the electromagnet may be reckoned at about 140 lb. per square inch of contact surface. Thus, an electromagnet to lift 1 ton will require about 15 sq. in. of contact surface. Of course, there must be a sufficient circulation of current. To give this flux-density to soft iron, when there are no gaps in the magnetic circuit, the circulation to be provided by the magnetising coil must be about 80 ampere-turns for each inch length of iron core to be magnetised.

In this ring experiment, if the mean diameter of the ring be 10 in., the total length along the iron will be about $31\frac{1}{2}$ in., and 80 times $31\frac{1}{2}$ is 2,520. We need, therefore, a circulation of 2,520 ampere-turns. If our battery can give us, say, 6 amperes, we shall need a coil of $2{,}520 \div 6 = 420$ turns. For then, 6 amperes going 420 times round, will be a circulation of 2,520



28. CRANE EQUIPPED WITH MAGNET TO LIFT PIG-IRON

ampere-turns, as required. With such a magnetising force the flux-density will be about 100,000 lines per square inch, giving a pull of 140 lb. per square inch of contact. And if each of the two surfaces has 1 sq. in. of area, the total force with which the one half of the ring is drawn to the other will be about 280 lb.

In all this it will be realised that to magnetise the iron the electric current never goes into the iron at all—it merely circulates around outside it.

If in any apparatus the pieces of iron that come into play do not fit together into a closed shape—if, in other words, there is a gap, or gaps, in the magnetic circuit—then a much larger amount of electric circulation is needed to excite the magnetisation, since air, or any non-magnetic material, has a much lower conductivity for the magnetic lines than is possessed by iron. Any electromagnet that is intended to pull at an armature which is separated from its poles by a wide air gap must, therefore, be so designed that a relatively much greater quantity of copper wire can be wound on its core.

Lifting Magnets. In the industries advantage is taken of the great tractive forces of electromagnets by designing special forms, as *lifting magnets*, for handling heavy billets of iron, steel plates, and ingots. A simple form of lifting electromagnet suitable for holding on tight to flat plates or blocks of iron is that depicted in **27**, consisting of a central iron core with an external iron jacket. In the cylindrical channel between core and jacket the exciting coil is embedded. The author possesses a small lifting magnet of this type, weighing 1·7 lb. only, and having just 2 sq. in. of surface at the working face. The exciting coil weighs only 5½ oz., yet this magnet will hold on to an iron block with a force of about 340 lb. when the current is on.

Fig. **28** depicts a much larger lifting magnet, in use by the Lackawanna Steel Company, of Buffalo, New York. A magnet such as this can be made to pick up a load of several tons at a time. Control is by switches, which turn the exciting current on and off.

Electromagnets for Attracting at a Distance. We have seen that if there is a gap between the iron and the poles of the magnet a much larger amount of electric circulation will be needed to excite the magnetisation than is the case where the iron is in contact with the magnet. The reason of this is that air is a poor conductor for the magnetic flux, because if there be an air-gap in the path of the flux, the amount of that flux will be greatly reduced, and hence the pull will be greatly reduced thereby.

But there are innumerable cases in which electromagnets are required to pull at an iron armature that is not in contact with the poles—cases, in fact, in which the electromagnet is employed to produce a movement of some part, as in an electric bell, or as in a Morse telegraph sounder.

Now, as a rule, the form of magnet that is suitable for the purpose of sticking on tight—as a lifting magnet—is not suitable for this other purpose of acting at a distance across an air-gap to produce movement. For if the magnetic flux must be forced to cross this gap, with a sufficient density of the flux to produce a fair pull, there must be provided a much greater circulation of current—more ampere-turns—than would have sufficed to excite the magnetism in a magnetic circuit without gaps. Now, if more ampere-turns are to be provided, it follows that the bobbins, or coils, must have more turns of wire, and therefore must either be of greater diameter, or larger. They are indeed usually larger, and therefore the magnet cores on which the bobbins are fixed must be longer. Any electromagnet which is intended to pull at an armature which is separated from its poles by a wide air-gap must, therefore, be designed so that a relatively much larger quantity of copper wire can be wound on its cores. This accounts for the telegraphers' rule that an electromagnet intended to reach out into space must itself have long limbs. On the other hand, an electromagnet intended merely to stick on tight to its load may be made of very short limbs of large cross-section. As a very rough rule, it may be stated that for every inch of length that a magnet is required to reach across the air to its armature, its own limbs must be a foot long.

Any electromagnet intended to be operated with very small currents ought to be wired with a coil of many turns of fine wire.

Electromagnets for Long Lines. In the cases where electromagnets are needed for use in sending signals through long lines—over distances of many miles—it is obvious that strong currents cannot be used, because to carry a strong current a thick wire would be necessary as the conducting line, and the cost of the copper would be excessive. Therefore, any electromagnets that are to be operated through long lines must be wound with many turns of fine wire. As an example, the coils inside telephone receivers and in telegraphic relays are always wound with fine wire, so as to get many turns upon the bobbin.

Current Density in Electromagnet Coils. To carry a current of 1 ampere, a moderately thin wire will suffice. A No. 20 standard wire-gauge, the diameter of which is 0.036 in., will, without overheating, carry more than 1 ampere if used as a line wire stretched in the air, and if coiled up in a coil will carry 1 ampere without overheating. Since the currents used in telegraphing are much smaller—from 4 to 10 thousandths of an ampere—thinner wires than this can be used for the coils of telegraph instruments. On the other hand, the currents used in electric lighting are much larger; ordinary arc-lamps take from 5 to 10 amperes, and thicker wires are required. In the coils of electromagnets, where there is no ventilation to disperse the heat, a suitable cross-section to allow for the wire is about $\frac{1}{600}$ or $\frac{1}{700}$ of a square inch for every ampere. If the magnets are needed for intermittent service only, so that they have time to cool, the permissible current-density may be at least five times as great as this.

To be continued

Group 22
MUSIC
4

Continued from page 366

A STUDY OF INVERSIONS

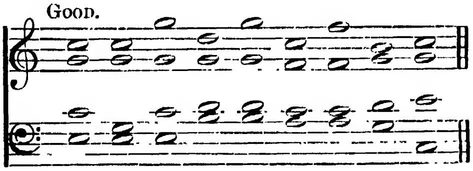
Inversions of Common Chords. Discords. Suspensions. Passing Notes. Modulation. Figured Bass. Harmonising Melodies

By J. CUTHBERT HADDEN

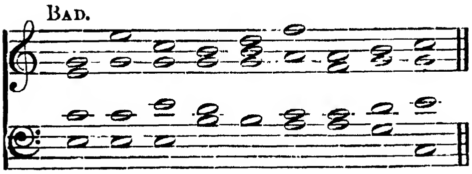
PROCEEDING now to a detailed study of inversions, we observe at the outset that first inversions of every triad in the major scale are allowed, while second inversions are allowed (by the theorists) only in the case of the tonic, dominant, and subdominant chords. First inversions, as such, are not subject to any restriction, and should be used whenever they promote the melodic flow of the bass. What we have to notice particularly about them affects the question of doubling. As in the root positions, the best note to double is the root itself, now the sixth from the bass note; when the context does not allow of that being done, then the other notes may (sometimes indeed *must*) be doubled. Certain chords, however, are subject to exceptional usages in the matter of doubling. Thus, in the first inversion of the dominant triad, the leading note of the key is the bass note, and this, being a peculiarly delicate constituent, should in no case be doubled. The same rule holds with regard to the first inversion of the imperfect triad on the leading note, where the sixth is the leading note and must not be doubled. In this chord the bass note should be doubled.

In the first inversion of all *major* triads it is inadvisable to double the bass note because it is the major third to the root. Reducing all this to a simple rule which the student can commit to memory, we say: In first inversions of common chords double either the third or the sixth (the original fifth and the root), whichever is most convenient, but avoid doubling the bass note. To emphasise this to the eye, we quote an illustration from Sir John Stainer's Harmony Primer:

Good.



Bad.



The last two chords in each case are, of course, in their root positions.

Second inversions of common chords are hedged about with several restrictive conditions which will at first appear somewhat perplexing. Recall the fact that such inversions are allowed only on the tonic, dominant, and subdominant chords. As regards the second inversion of the tonic, its use is very largely, if not mainly, cadential. That is to say, it is a determining factor of the perfect or the imperfect cadence. Thus at *a* we see it in the perfect, at *b* in the imperfect cadence.

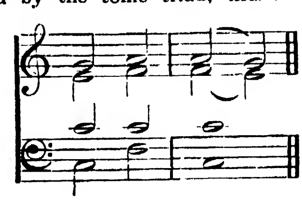
(a) (b)

In both cases the same bass note (G) bears two different chords—first, the second inversion of the tonic, and second, the dominant in its root position. This is quite "the most usual way of following the second inversion of the tonic," in which, by the way, the bass note is nearly always doubled.

The second inversion of the dominant, with the supertonic in the bass, is less restricted in its use, though it is generally both preceded and followed by the tonic chord or its first inversion.

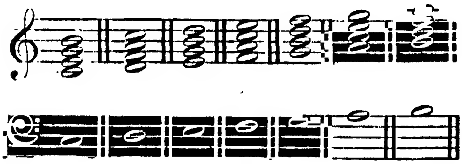
It should be approached and quitted by step, and the bass note may or may not be doubled, according to convenience. The sixth from the bass, being the leading note, must never be doubled.

Of the second inversion of the subdominant there is little to say, except that it is preceded by its own chord in the root position and followed by the tonic triad, thus:



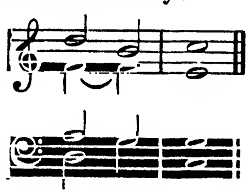
In this way it may be regarded as a sort of ornamentation of the plagal cadence, already described.

The subject of discords and how to treat them is so vast that only its fringes can be touched here. The student already knows what a dissonant interval is. When such an interval is introduced into the common chord, the result is a *discord*. The common chord, we have seen, is a combination of two thirds, one placed above the other. If we add still another third, we immediately produce a discord, for the added note is a seventh from the root, and the seventh is a dissonant interval. Chords of the seventh may be formed on every degree of the scale, as here:



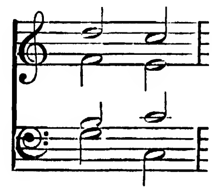
Of all these, the chord of the seventh on the dominant is the most important, inasmuch as from its combining those sounds which do not belong to any other scale it decides the tonic harmony Thus in the above example, the fifth chord could not possibly be in any other key than C. Take it into the first sharp key (G) and you have to sharpen the F, into the first flat key (F) and you must flatten the B. The student should therefore master this chord before attempting to deal with other chords of the seventh.

Prior to a study of the chord itself, we must, however, learn of two essential conditions attendant upon the use of discords. These conditions are (1) that the dissonant interval must be *prepared*, and (2) that it must be *resolved*. By preparation is meant the use of the coming dissonant note as a *consonance* in the previous chord, generally, too, in the same part. By resolution, again, is understood the passing of the dissonant note to a concord in a regular defined way. Thus, in the following illustration, the dissonant F in the dominant seventh is "prepared" by being struck as a consonance in the previous supertonic chord, while its "resolution" follows naturally upon the E of the tonic harmony:



The resolution of all discords whatsoever is imperative. Such resolution may indeed be delayed, and it may be irregular, but "the feeling of *rest* in a concord must follow sooner or later." The law as to preparation is not so strict. Dominant discords, for example, are allowed without preparation, and there are other exceptions. For the present the student, if he makes exceptions at all, should except only the dominant discords.

Now we will look at the dominant seventh. We have said that here the seventh need not be prepared. How, then, is the chord resolved? In the natural resolution the seventh descends one degree; the third, as leading note, ascends one degree; the fifth either ascends or descends; and the bass proceeds to the tonic by ascending a fourth or descending a fifth, thus:



There are other "resolutions"—for example, on the triad of the submediant; on a second inversion on the same bass note; and on one of the dominant seventh's own inversions. In all these cases, however, the seventh must descend one degree, and the leading note (except in the last case) rise to the tonic. When it is necessary to omit some of the constituents of the dominant seventh, the fifth and eighth of the bass may, with least consequence, be omitted. Neither third nor seventh ought ever to be omitted; nor should these intervals be doubled, for, having a fixed progression assigned to them, they would, if doubled, make consecutive octaves. The dominant seventh has, of course, three inversions, all of which are in frequent use.

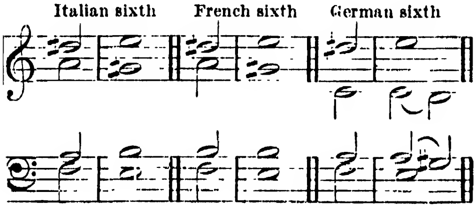
With regard to chords of the seventh on the other degrees of the scale, the essential thing to remember is that they demand the regular preparation of the dissonant note; which, again, must always be resolved by descending one degree. The bass, in all ordinary cases, ascends a fourth, or descends a fifth. These "secondary sevenths," as they are sometimes called, are not extensively used. That on the supertonic is the one most frequently met with, and, among the inversions, the first is in most general use. Some theorists disallow the second inversion entirely.

The dominant chord bears out its name in many ways. Thus, it forms the foundation of the elaborate dissonances of the ninth, eleventh, and thirteenth, in addition to the seventh already considered. These chords are formed by a continued superimposing of thirds, as thus:

Their introduction should be left to advanced students of harmony. Two very important

chords derived from the dominant seventh must, however, be noticed here—the chords of the diminished seventh and the augmented sixth. The first may be produced by taking any chord of the dominant seventh, and raising the bass a chromatic semitone, as here:

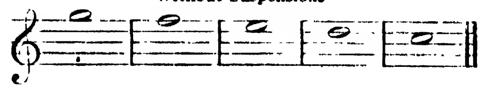
All three inversions of this chord are freely employed. The chord of the augmented sixth is found on the submediant of the minor key. It has three forms, known respectively as the Italian, the French, and the German sixth. We give an example of each:



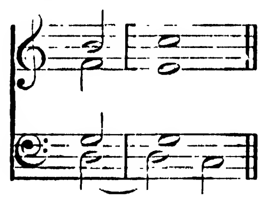
In the case of the German sixth, it will be observed that it is necessary to introduce a second inversion previous to the resolution, in order to avoid consecutive fifths. A very great deal might be said of these beautiful chords and about others derived from them, but it will be enough for the student to become familiar with them on paper and by ear.

A word or two about *suspensions*, so called. A suspension occurs when a note (there may be two notes) of one chord is carried into the following chord. Thus, if we write

we have what is technically termed a suspension of 9 to 8—that is, a ninth (D) above the bass passing to the octave or eighth. The most common dissonances of this class are the ninth suspending the eighth, the seventh suspending the eighth, the fourth suspending the third, and the sixth suspending the fifth. This will be made clear by comparing the following descending melodic phrase, accompanied with its fundamental bass, first without and then with suspensions.



The ninth and fourth should generally be prepared, the first by third, fifth, or sixth, the second by any concord. The ninth ought never to be prepared by the eighth, otherwise consecutive eighths would occur. When the bass is suspended, the suspension is often termed *anticipation*, but the distinction seems pedantic and unnecessary.



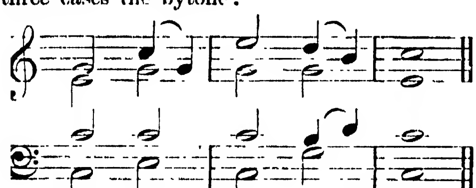
So far, the harmonies considered have introduced no notes but those essential to the respective chords. We have now to notice the case of unessential notes, incidentally thrown in between one chord and another. These are known as *passing notes*. They may be defined very shortly as scale sounds lying between notes essential to the harmony but not themselves essential. Their nature will be readily understood from this illustration, where the passing notes are marked x:

The purpose of such harmonically unessential notes is to impart variety, brightness, and continuity of movement to a part or parts. Generally they are taken at the unaccented portion of the beat, though there is no rule prohibiting their use at the accented part. Sometimes they are approached by a skip; but in any case it is advisable that they should move upward or downward, according as they are approached from below or from above.

They can be taken in two or more parts at a time, but in that case they must either be consonant with one another, or, if dissonant, must move in contrary motion. See, in illustration of these points, the following bars from a chorus of Handel, the passing notes being printed small size:

A passing note, it should be observed, is not allowed to excuse a progression of parts which would be faulty without it.

What are termed by some writers *harmonic bytones* are often classed with passing notes. They serve, indeed, practically the same purpose, but they *belong to the chord* in which they occur, and have therefore no theoretical connection with the passing note strictly so called. Here are examples, the second crotchet being in all three cases the bytone:



These bytones being actual constituents of the chord, the student must take care that, in introducing them, he does not leave the chord without one of its essential notes. Thus, if the B in the treble of the above illustration had not been introduced as a companion to the D of the tenor, the chord would have been bereft of its third, and that third the leading note too.

We must now say something about *modulation*. By this term is understood the passing from one key to another. Few compositions, however short, remain in the original key throughout. They would be very monotonous if they did; the ear demands a change of tonality. Modulation is entirely a matter of harmony. A melody may *imply* a change of key, but no actual change can be effected without attendant chords. The modulations most frequently introduced are those by which the music is taken into the keys of the dominant or subdominant, as from C to G or C to F. Such modulations can all be brought about by very slight changes in, or additions to, one or other of the chords of the original key. Thus, take a modulation to the subdominant as at *a*. Here we have simply to add a minor seventh to the tonic, which latter thus becomes the dominant of a new scale, the scale of F. Again, at *b* a modulation to the dominant is easily and naturally effected by making the third of the chord of the supertonic of the original scale major and adding a seventh to it. Once more,

(*a*)

we may modulate into the relative minor, as at *c*, by making the third of the chord of the mediant major and adding to it a seventh.

It is now that the student will come to realise the great value of the dominant seventh, for it is by this chord and its inversions that the very large majority of modulations are managed. The old tonic becomes the root of the new dominant seventh, and by the fixed resolution of the latter we are brought into the tonic harmony of the new key, which is thus at once established in the ear. There is no more obvious, more rapid way of effecting the commonest modulations than by this all-important chord. Of course there are many uncommon and abrupt modulations, and every modulation, common or uncommon, admits of great varieties of treatment.

To be continued

DRAINAGE APPLIED TO BUILDING

Pipes. Channels. Traps. Yard and Special Drainage Systems and Materials. Water Gullies. Road Gullies. The Work of the Drainlayer

By Professor R. ELSEY SMITH

Objects of Drainage. The objects to be arrived at in a modern system of drainage as applied to individual buildings are (1) to convey away the sewage without any risk of contaminating the land through which the drain is carried; (2) to ensure that the whole system is one that shall be self-cleansing and shall be effective even under the conditions of complete want of attention which usually prevail; (3) to provide means of ascertaining readily the causes of any interference with the regular working of the system and for promptly dealing with such interference; (4) to provide against the possibility of introducing into the building by means of the system of drainage the poisonous gas generated in the sewers and cesspools, and even to some extent within the system itself.

These are the most important requirements which must be borne in mind in dealing with a system of drainage, and to provide for meeting them, not only good design, but the best materials and workmanship are essential. The tests applied to a drainage system are properly severe. The work is almost entirely buried out of sight, and in most cases, unless a defect shows itself, it receives no attention from year's end to year's end, and it is therefore of the highest importance to secure conditions that shall be as good as possible.

The drains of an ordinary building consist of a series of tubes through which the matter to be conveyed flows until it is discharged into a public sewer or cesspool, or is distributed over land or otherwise dealt with. [For treatment of sewage, see CIVIL ENGINEERING.]

System and Materials. There is often a double system of such tubes, one of which is reserved for water which is clean and practically free from solid matter or contamination, and usually consists principally of the rain-water collected from the roofs of any building; these are described as *rain-water drains*. The other receives all foul water, including the discharges from water-closets, urinals, sinks of all kinds, and bath and lavatory wastes, all of which contain putrescible matter and are liable to rapid decomposition and to generate a gas known as *sewer gas*, highly injurious to health. These are generally classed as *soil drains*, a term more particularly applied to those conveying discharges from water-closets. The circumstances of various buildings differ widely, but whether an isolated country house or a town building is to be dealt with, certain principles must be observed, and the actual methods of construction are to a large extent identical.

The materials used in the laying of a drainage system are to a considerable extent ordinary building materials. The preparation and laying of concrete has been already dealt with. Certain work in bricklaying must be referred to, but for fuller explanations of the bricklayer's work see BRICKLAYING. The materials now to be considered are those employed in the actual formation of the drains—*pipes, channels, bends, traps* of various forms. [For the construction of large sewers and conduits, see CIVIL ENGINEERING.]

Pipes. These must be straight, true in section, absolutely impervious to water, not easily liable to fracture, and of material that will not be affected by the acids contained in the sewage, and the inner surface must be perfectly smooth and offer no obstruction to the flow of its contents. It is desirable that the diameter of the pipe should be as small as possible, provided it is adequate to the maximum flow, so that at periods of minimum flow the depth of water in the pipe compared with the area of that part of the invert covered by it, described as the wetted perimeter, should be as large as possible. The materials used for such pipes are *glazed stoneware, glazed earthenware*, and *glazed terra cotta* and *cast iron*. The various forms of earthenware pipes referred to are all similar in form [for manufacture, see POTTERY], and are almost always salt glazed. They are usually about 2 ft. long [**12**]. One end is formed with a socket to receive the other, or *spigot* end, of the next pipe. The outer surface of the spigot and the inner surface of the socket have, as a rule, fine annular channels formed on them, their purpose being to assist the adhesion of the cement.

The internal surface must be thoroughly glazed, and free from all excrescences and roughness which would check the flow of sewage, and pipes should be inspected to ensure this. A slight roughness or projection in one spot need not necessarily lead to condemning a pipe, but care must be taken to see in laying that such defect is placed not in the invert, but at the top of the drain. Such pipes are made of various diameters, from 3 in. upwards. The thickness of the material in stoneware pipes is usually $\frac{9}{16}$ in. for 4 in. pipes, $\frac{11}{16}$ in. for 6 in. pipes, and beyond this size $\frac{1}{12}$ of the diameter. There are some variations from the general type. *Taper pipes* are formed which are regularly reduced in diameter from one end to the other [**16**], and may have the socket formed on either the large or the small end. *Cleansing pipes* [**17**] are employed for building into manholes that are not fitted with traps, but have a kind of hood-shaped enlargement formed at one end, increasing the vertical but not the horizontal diameter to facilitate the introduction of cleaning rods.

A rougher class of pipe is used for land drainage, where the important consideration is the collection and removal of water which percolates through the ground, and which is not contaminated with sewage.

These are known as *agricultural drain-pipes*, and are short tubes from 2 in. to 6 in. in diameter, formed of burnt earthenware, without sockets, and unglazed. They are laid end to end, and are not jointed. Their purpose is to give free passage to the water collecting in the trench in which they are placed, and which can enter the pipe at any joint. They are sometimes used for passing water collected by embankments through the base of the wall to the front, and for this purpose are embedded in the concrete or masonry, and are known as *weeping pipes*.

Bends. These are pipes so formed as to change the direction of the axis of the pipe. They are made to a great variety of curves, from a quadrant [18] to a very flat bend. They should not be used in soil drains, but may, if necessary, be used in rain-water drains.

Junctions. Various forms of these are manufactured. They may be Y-*junction*, single, or double [19], and they may be arranged so that the inlet joins the main pipe at various angles; but it is undesirable that the angle between the axis of the two drains should exceed about 45°, and right-angled junctions are not tolerated, as nothing is more apt to produce an obstruction in the drain. Junctions are often made between pipes of different size—*e.g.*, one of 4 in. diameter may join one of 6 in. Junctions, like bends, should only be employed for rain-water drains, and not for soil drains.

Channels. These are open pipes [20]; usually semi-circular, and with half-sockets. They are used sometimes for the conveyance of surface water at the ground level; in a drainage system their special use is to enable junctions to be made between various soil drains. The manner of using them will be more fully described in connection with the construction of *manholes*.

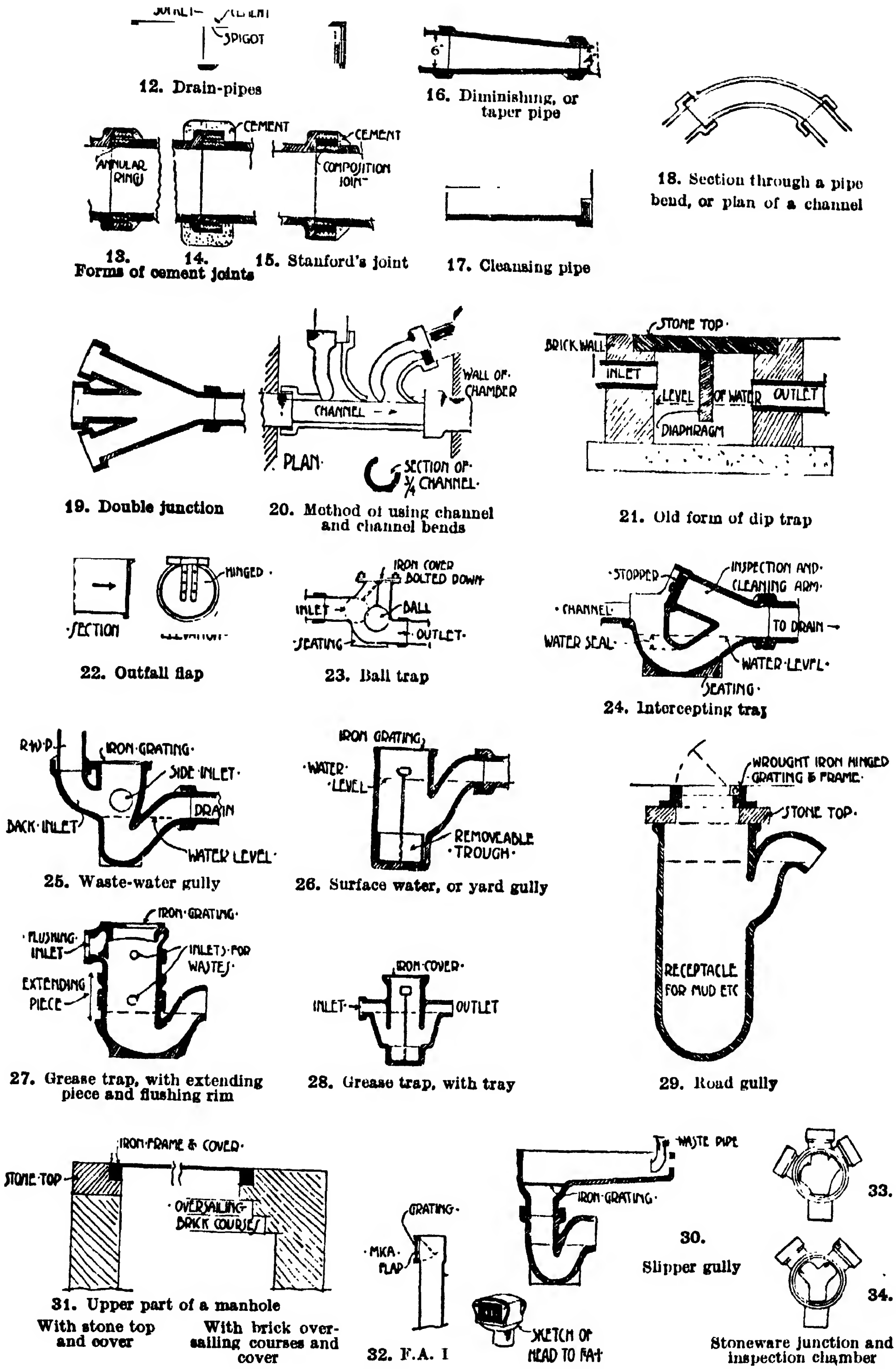
Taper channels are formed in a manner similar to taper pipes. *Bends* are also formed in channels [18], and for some forms of bend the section, instead of being semi-circular, is a full three-quarter circle [20]. There is a much greater variety in the form of *channel bends* than of pipe bends, as in some cases it is necessary in forming manholes to bring in a branch drain from a direction that will require the flow of the contents to be almost reversed in the manhole [20], and it is mainly in the case of such bends that three-quarter channels are required, the outer side of the bend being covered in to retain the flow of water in the channel, which without such protection would tend from its own velocity to overflow it, and deposit any solids on the sides of the manhole. For this extreme case, bends of a great variety of radius and of different lengths may be procured to fit almost any angle at which a drain can be received, a slight adjustment being always possible. The upper end of any channel is provided with a socket, and is at right angles to the axis at this point, but the lower end is splayed so as to be parallel to the axis of the central channel where it is employed to form a junction.

Traps. These are devices to prevent the return of the sewer gas from the sewer to the building. The earliest [21] form consisted of a small chamber in the line of the drain sunk below its general level, with a *diaphragm* fixed across it extending from the top of the chamber to below the level at which the water would stand in it. A barrier is thus interposed, closing the upper part of the chamber and the drain above it against any return of an air current, while not preventing the flow of the sewage underneath the diaphragm. This was known as a *dip trap*. If well constructed, it was efficient so far as its special purpose was concerned, but had various drawbacks—it checked the flow of the sewage, and solids were apt to be deposited in the chamber and block it, and it was not easy to make, and keep it, air-tight. Such traps are no longer used, but the principle of the dip trap is employed in all forms of traps, the essential feature being the interposition of a barrier in the course of the pipe that will, under ordinary conditions, prevent the return of air up the pipe. Such traps, however, are now formed of the same material as the pipes, and though some of them are made in more than one piece, the portions containing the barrier between the outlet and the basin, in which water always stands, are of a single piece.

The barrier is formed in various ways in different traps, but always extends below the level at which water stands in the trap; the bottom of the outlet is arranged at a higher level than the bottom of the barrier. The pipe is thus actually closed or sealed by the body of water always standing in it against the upward passage of air or gases, while allowing water or sewage to flow through it. The depth to which this barrier penetrates below the surface of the standing water is referred to as the *depth of the water seal*.

Modern Forms of Trap. The modern forms of intercepting trap [24] are made by introducing into the length of the pipe a bend of such a character that the upper part of the pipe dips below the water-level forming the seal, while the lower part of the pipe forms a basin to retain the liquid. The lower end is formed with an ordinary spigot to join the drain below; the upper end has a half-socket to receive the channel. The upper half above the seal usually dips sharply; the lower, or outlet half has a more gradual rise, the object being to interpose as little check to the flow of the sewage as possible; and where the conditions of the drainage system permit, the upper side may have a cascade formed by keeping the inlet at a higher level than the outlet, so that the flow is discharged into it with a slight impetus.

The form of the trap makes it impossible to introduce a cleaning rod through the trap itself, and an upper arm is provided for this purpose. This is carefully closed when not in use, or the utility of the trap would be destroyed; but the stopper closing it may be attached by a chain



12. Drain-pipes

13. 14. Forms of cement joints

15. Stanford's joint

16. Diminishing, or taper pipe

17. Cleansing pipe

18. Section through a pipe bend, or plan of a channel

19. Double junction

20. Method of using channel and channel bends

21. Old form of dip trap

22. Outfall flap

23. Ball trap

24. Intercepting trap

25. Waste-water gully

26. Surface water, or yard gully

27. Grease trap, with extending piece and flushing rim

28. Grease trap, with tray

29. Road gully

30. Slipper gully

31. Upper part of a manhole. With stone top and cover. With brick oversailing courses and cover

32. F.A.I

33. 34. Stoneware junction and inspection chamber

SECTIONS OF DRAIN-PIPES AND FITTINGS

As these goods are made in various sizes, no scale is shown

to the upper part of the manhole, so that, should the trap become stopped and the manhole filled with sewerage or water, the plug may be withdrawn and the chamber emptied.

Such an intercepting trap is used in a drainage system at or near its termination, before it enters the sewer or cesspool, to intercept the return of sewer gas. Various makers manufacture them in a variety of forms, but the essential as described above should be found in all of them.

The Problem of Back Flow. It happens occasionally that a drain is subject to a back flow of water or sewage from the sewer. This may arise when the outlet discharges into a tidal river at times of exceptional tides, or, in the case of a sewer being of inadequate size, on the occasion of exceptionally heavy rain. This is not easily dealt with ; no form of check that does not act automatically is of any great value in most cases.

Flaps are sometimes placed at the outfall of a drain [22], which, on any back pressure arising, should close the outlet till such pressure is removed ; but this must be applied in the sewer, and in small sewers it cannot always be adopted. A form of trap designed to meet such cases is the *ball trap* [23]. This is provided with a hollow metal ball that, under ordinary circumstances, leaves the orifice free, but if any back pressure arises is lifted by the returning water and is pressed against and closes the orifice. This device is open to the objection that the orifice, or the ball, may become somewhat foul from the sewage, and may not close properly, but it has been found efficient in many cases. The ball is sometimes hung with a hinged joint from the top, and in some cases is loose, the trap being designed so as to guide it into position when floated.

Gullies. Traps are required in many other situations, and take various forms. Those termed *gullies* are intended to receive the discharge from sinks and rain-water pipes, yards, paths, &c., and are open to the air at the top. Their object is to prevent any pipe which is connected with the inside of the building, or the top of which terminates near a window, from having a direct connection with the drains. The discharge may take place above a grating placed at the top of the gully [25], but this grating may get stopped through the deposits of solids in the discharge itself, or through an accumulation of leaves, or to some accidental circumstance, and the discharge will then not enter the drain, but overflow around it and soak into the ground. Pipes should therefore discharge into a gully below the level of the grating, a small pit being formed, if necessary, for this purpose and covered with a grating. For many pipes a good method is to connect the ends directly to inlets provided at the back or sides of the body of the gully.

Some makers provide gullies with extending pieces [27], so that the gully may be sunk to any required level below the ground. Such pieces may each have one or more inlets provided, so that the gully may receive the discharge from several pipes. Gullies which are formed of two or more pieces must be jointed. The upper part is adjustable to the pipe, the lower part to the drain.

Yard Gullies [26] and Surface Water Gullies. These differ from the ordinary gully in the manner of forming the seal and in the form of the bottom ; this is made deep, and the outlet is kept near the top so that the body forms a catch pit which will retain any sand, gravel, or other solid material washed into it during heavy rain, and prevent it from passing into the drainage system. Such gullies are often provided with metal receivers fitted with a handle ; these are placed in the bottom and receive any solids, and can be lifted bodily out, emptied, and replaced. The lower part of the gully may be made deep and of considerable capacity, and the water seal should also be deep, as in dry weather such gullies are very liable to lose the water which forms the seal by evaporation.

The Road Gully [29]. This is a variation of the form of gully last described, and has a very large body or container sunk deeply below the trapped outlet, and capable of holding a considerable bulk of material washed from the road surface. These are usually emptied periodically by means of long-handled scoops.

The use to which scullery sinks are put results in the discharge of a great deal of greasy matter into the drains. When this leaves the sink it is often quite hot, but on being discharged into the water standing in a trap it becomes chilled, the grease congeals, and is very liable to foul the drain which carries it off, adhering to the sides and decomposing. To meet this difficulty *grease traps* are provided.

Grease Traps. The object of these is to retain the greasy matter in the trap till it has congealed. To achieve this the body of the trap is made large, so that a considerable bulk of water is retained in the trap and is always cool or cold. The outlet is considerably below the surface. The grease, on entering the trap, rises and collects on the surface, and there congeals.

There are two methods of disposing of this congealed grease. The first is to provide a form of tray that can be lifted out, bringing out the grease, which must be burnt or otherwise disposed of [28]. There is, however, a great probability that the duty of regularly cleansing out such a trap will be neglected. The more satisfactory method is to supply a trap provided with a flushing rim [27], such as is found in the pan of a water-closet, and to connect this with a tank which discharges automatically at fixed periods a considerable body of water into the trap through the rim, and which completely flushes out the trap, breaks up the congealed grease, and carries the whole through the drain with the flush of water. The amount of water used each time is determined by the size of the cistern, and depends upon the use which is made of the trap. The frequency of the discharge is capable of regulation.

To be continued

ELECTRICAL, WATER & GAS ENGINEERS

The Most Promising Branch of Municipal Work. Tramways Department. Theoretical Qualifications. Well-paid Municipal Offices

By ERNEST A. CARR

[illegible] study of the various branches of municipal engineering has as yet been restricted to the borough or county engineer's department, and to that of the surveyor. To complete the task, we have to consider the three special classes of engineering associated with the municipal supply of electricity, water, and gas. In the larger boroughs each of these forms a separate department of the staff; in others they are under the general control of the surveyor or engineer.

Electrical Engineers. "Which do you consider the most promising department of local government work for a youth to enter?" was lately asked of a borough official of high standing and of many years' experience. His answer was a model of terseness: "The electricity branch." Another expert, to whom the same query was addressed, replied: "Undoubtedly the engineering, especially electrical and traction."

The reasons for these replies are not far to seek. The application of electricity to the public service has proved of immense value, and is developing with startling rapidity. During the last 10 years the income of local authorities from electricity works has increased 800 per cent., and from tramways (chiefly electric) no less than 2,500 per cent.! A network of municipal tramways, telephones, and electric lighting systems is fast overrunning the busier districts; new departments are formed, often with a large staff to work them, and with each fresh development the scope afforded to capable engineers is enlarged.

As yet, indeed, the demand for highly trained electrical engineers has been equal to the supply—a surprising state of things when we consider the congested state of the labour market generally. In a few years' time matters will doubtless have adjusted themselves, and only the possessors of recognised diplomas will be selected for chief appointments. Meantime such posts are often awarded—notably in the tramway works—to men who have proved themselves practical experts, but whose paper qualifications are of the scantiest.

Liberal Remuneration. A further attraction is the marked tendency of local authorities to deal liberally with their electrical engineering staff. Nor is the tendency surprising, for electric works are often not only very successful in themselves, but highly profitable to the ratepayers. Thus, in a single year's working the electric trams in Manchester earned a net profit of £120,950; in Glasgow, £93,257; and in Liverpool, £32,081. On electrical works generally, excluding tramways and their huge gains, no fewer than 115 towns that year made a profit, great or small, amounting in all to £436,000.

For such satisfactory results—the more satisfactory because obtained in spite of high wages and low charges—credit is chiefly due to the various electrical staffs. It is only just, therefore, that their services should be liberally recompensed. This striking passage from an utterance of the Lord Provost of Glasgow applies with particular force to such work as theirs: "It will be an evil day for the municipalities when those who are the captains of their great departmental industries are not rewarded with material recognition on a scale adequate to the services rendered."

Principal Appointments. The larger boroughs owning important electrical works place these in charge of a chief electrical engineer. Where a tramway service is included, his post is both lucrative and very responsible. In any event he ranks among the best-paid members of the staff.

A successful officer of the front rank must have had a sound scientific and practical training in electric and mechanical work, and especially in traction, lighting, and permanent-way engineering. He should, further, be a man of energy and ideas, with good organising powers, who is in touch with every new scientific or commercial development that may affect his work, and competent to give advice on questions of principle, and on the many types of electrical apparatus in the market. The engine-house, power-station, and sub-stations are under his control, with their boilers and superheaters, generators, dynamos, batteries, switch gear, and every other item of the service system—and perhaps the dust destructor also, as a source of useful heat. In brief, he must be a shrewd, practical expert in every method of generating, transmitting, and distributing electrical energy.

Tramways Engineering. In many boroughs the electrical engineer's duties are combined with those of tramway manager. Other authorities keep the two posts distinct. The latter office, however, is in itself an engineering appointment, though the standard of training exacted is not always high, and many duties of supervision and business detail are added. For either post the salaries paid range high wherever the electric traction is considerable; and we may conveniently discuss both positions together.

London's tramways manager receives £1,500 a year, and its chief electrical engineer £1,000. The Manchester Corporation pays each of these officials £900, and the tramways electrical

engineer £300; while the manager of the city traction at Belfast receives £1,250, to be ultimately increased to £1,500. A chief electrical appointment of average value is probably that of Newcastle-on-Tyne, which begins at £700 a year, and increases by £50 yearly to £800.

Smaller electric services naturally involve lesser stipends. Thus, in two London boroughs (neither, of course, owning tramways) the commencing salaries of the electrical engineers are £600 and £400 respectively, and at Bournemouth also the latter figure is paid. Similarly, the stipends of the tramway managers at Brighton, Huddersfield, and Leyton are respectively fixed at £300 (rising to £400), at £350, and £300.

Chief engineering posts under the minor authorities—the tramless small towns and busier urban districts—are scarcely of professional rank. They often involve merely the charge of a small lighting station and a working staff. The salaries paid vary from £150 to £400, according to the plant and electrical output.

Consultant posts in municipal electric engineering may be dismissed in a few words. Consulting engineers are recognised experts in private practice, who are retained by local authorities to advise their engineering staff in the execution of electric works. They are remunerated either by fee or at a "retainer," which may be £150, £300, or £500 a year, according to the nature of their services.

Qualifications. A good many of the foremost electrical positions in the municipal service are held by graduates in civil engineering, and by Associate Members of the Institution of Civil Engineers. The diplomas of the Institution of Electrical Engineers—M.I.E.E. and A.M.I.E.E.—are at least as frequent, and are sometimes coupled with those of the Institution of Mechanical Engineering. [See ENGINEERING.] Other officers—and those by no means the least capable—can boast no higher certificate than those of the Board of Trade, or the City and Guilds of London Institute—for the councils making appointments naturally pay more regard to a candidate's proven record in practical engineering than to the regularity of his training; and some of the engineers in charge of small undertakings may be said to have graduated in the municipal workshop.

Especially is this true of certain of the semi-professional posts already discussed—such as tramways manager, or manager and engineer jointly, to the lesser authorities. In some instances the manager has been selected from the working engineering staff, and in others by promoting a traffic superintendent who had qualified by supplementing his working knowledge of tramways with such evening studies as he could pursue.

The Need of Scientific Training. To have been successful under such arduous conditions reflects the greater honour on the men who accomplished the feat. We are considering the service, however, from the standpoint of the prospective candidate. It is, therefore, essential to bear in mind that, despite occasional successes of this character, the need of some scientific training in competing for electrical and tramway appointments is already great, and rapidly grows greater, and that to omit any available chance of thus qualifying is simply to handicap oneself severely in the contest.

Experience in municipal or private electric traction and lighting remains, of course, the supreme recommendation. It is noteworthy, therefore, that a number of borough electrical engineers receive articled pupils who have passed through a technical school, the premium charged varying between 30 and 150 guineas. On expiry of the articles, a post as assistant on the electrical staff of a local authority should be readily obtainable; and from that position the way to a diploma and a chief appointment is hard, but fairly direct.

Assistantships. There are a great many subordinate posts other than assistantships proper in the electrical department of a busy corporation. Many of these are worthy of the attention of fully trained men who wish to obtain a footing in the service with a view to a principal engineership. Others are within the scope of a clever, hard-working mechanic. Mains engineers and surveyors receive from £275 to £350, permanent-way engineers about £300, and the resident engineer attached to each station earns the same salary, or a little less. Assistant engineers of professional (as distinct from working) grade receive from £100 or £120 up to £350, according to their degree of experience and training. The London County Council lately offered a number of vacancies at £365 a year for "fully competent engineers, with good experience in the design and construction of the permanent way and general arrangement of electric tramways on the conduit and on the overhead systems."

Shift engineers, mains superintendents, and working engineers-in-charge, are paid between £150 and £220. For the rank and file the following rates of pay may be taken as typical: Foremen, £2 15s. to £3 15s. a week; working engineers and electricians, £2 2s. to £2 15s.

A Diploma a Strong Recommendation. The scientific training expected of candidates varies almost indefinitely, according to the needs of particular posts and the views of the appointing authorities. Usually no special qualification is insisted upon; but in seeking a professional assistantship, the rank of student, either in the parent engineering institute or its electrical offshoot, would form a strong recommendation. Apart from such training, the most useful equipment is a sound practical knowledge of engines and dynamos, generators and motors, and the special fittings for C.C. and A.C. (single and polyphase) systems.

It has always been a moot point whether large or small electrical undertakings furnish the best training-ground for the future engineer. In the former case the staff is generally better paid and the apparatus more complete; and the smallest works provide no experience in that

supremely important subject—electric traction. On the other hand, an assistant's work in a borough of moderate area is generally less specialised than in one of the great industrial centres, and affords a better "all-round" training.

Waterworks Engineers. Waterworks construction and control, as an important branch of civil engineering, will be found fully treated in our engineering course; and its municipal differs so slightly from its general aspect that little can usefully be added here. The following admirable summary of municipal work, however, is from the pen of a leading practitioner, and may be scanned with advantage. It was read before the British Association of Waterworks Engineers by the president, Mr. Philip H. Palmer, M.Inst. C.E., water engineer to the Hastings Corporation: "The practice of water engineering is becoming daily more technical and complicated, and deals with the important subjects of rainfall—the obtaining of accurate data being the prime factor in ascertaining the supply available from a given drainage area—geological considerations, losses by evaporation, discharge by floods, the regulation of fittings, quality of different kinds of water and their suitability for domestic or industrial purposes, filtration of water, designing of works generally, pumping plant, working of meters, and a general knowledge of mechanical work."

It need only be added that local authorities are paying increasing attention to the need of an adequate and pure water supply, and in many districts are devoting enormous sums to the construction of reservoirs, conduit systems, and filter-beds. All these activities improve the prospects of the capable engineer. A recent instance of such municipal enterprise is the supply of Birmingham with excellent water from huge reservoirs constructed in the Elan Valley, fully 70 miles from the city. The water supply of the whole area of Greater London has lately been municipalised by purchase from the various water companies owning it, and their large staff of engineers taken over.

Waterworks. The designing and execution of waterworks (as mentioned in the Municipal Engineering section) is usually entrusted to the borough engineer, with or without the aid of consultants. Sometimes, however, a waterworks engineer is specially appointed for the task. None but a very able civil engineer is competent for so grave an undertaking, and the salary paid is proportionately high. £1,200 to £1,500 a year are average figures for such duties.

For the control of existing waterworks the responsible engineer receives from £500 to £800 or £1,000 a year, and the resident works engineer between £250 and £400. The positions and salaries of a typical waterworks engineering staff (both professional and working) are indicated by the following list, compiled from the paysheets of an important corporation:

Waterworks Engineer, £1,000.
Engineer and Manager of Hydraulic Supply, £600.
Chief Assistant Engineer, £310.
General Surveyor of Water Mains, £600.
Assistant Surveyor of Water Mains, £280.
Local Surveyors, £200 to £280.
Works Inspector, £280.
Inspector of Fittings, £290.
Assistant Inspector of Fittings, £210.
Foreman Inspector of Pipe Laying, £180.

Gas Engineers. While gas continues to hold its own as an illuminant against the claims of electric light there will be no lack of scope for the municipal gas engineer. That it is doing so in fact seems evident from the latest Board of Trade returns. These show that 256 local authorities possess gasworks, and that the number is steadily growing. The latter fact is hardly surprising, in view of the following instances of yearly profits from municipal gas. Manchester, £60,000; Leeds, £30,000; Nottingham, Salford, and Belfast, £20,000 each; Blackpool and Bolton, £15,000. The field of municipal employment is thus both wide and full of promise.

The gas engineer's qualifications and prospects need not be discussed in any detail, for what was said on this score concerning his brother officials of the electrical and water works applies no less to himself. The sole material distinction is in the nature of his duties, which are a highly specialised department of mechanical and thermochemical engineering, rather than of electrical or civil engineering.

The Nature of the Work. The work of the gas engineer includes the construction and maintenance of retort-houses, gas-holders, and tanks, purifiers, sulphate works, waste liquor and tar tanks, and other gas plant, and their control in working. A special feature in modern gasworks is the manufacture from residual products of naphtha, pitch, benzole, sulphate of ammonia, and carbolic acid. The apparatus for these industries, and the carburetted water-gas plant, fall also within the province of the gas engineer, who must thus be something of a chemist as well as a mechanician.

As an instance of the important construction works entrusted to these officers, it may be mentioned that the enormous gasworks now in course of erection at Provan, Glasgow, and capable when completed of producing 48,000,000 cubic feet of gas daily, were designed by the late Mr. William Foulis, M.Inst. C.E., whilst engineer and general manager of the Glasgow Corporation's gas department.

Practically the same level of salaries prevails among public authorities for the gas as the water engineering staff. This is illustrated by the following table, compiled from the same source as that given above:

Gas Engineer, £1,000.
Superintendent, £700.
Deputy Superintendent, £450.
Superintendent (street mains), £450.
Deputy Superintendent (street mains), £325.
Stations Managers, £300 to £400.
Deputy Stations Managers, £225 to £250 (with house).
Foremen Mechanics, £175 to £180.

To be continued

THE MACHINERY OF DIGESTION

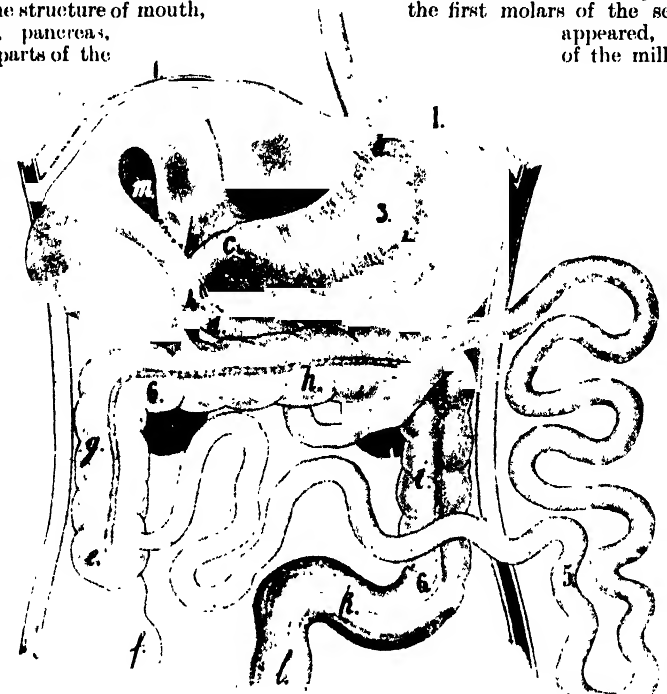
The Digestive System and the Organs of Digestion. The Teeth and Mastication. How the Food Descends. Throat and Stomach

By Dr. A. T. SCHOFIELD

WE have now done with the necessary preliminaries of the first two divisions of this section, and are free to study the systems in order, and travel through the body, viewing its structure, adaptation, and marvellous processes with interest and wonder.

We begin with digestion. Let us first observe the machinery engaged in the process, and then in a subsequent chapter we can follow the actual digestion, say, of a beef sandwich, until it is changed into flesh and blood. In this chapter, therefore, we will consider the structure of mouth, stomach, liver, pancreas, and bowels as parts of the great digestive system.

The food is introduced into the body and digested in a special tube [25] called the alimentary canal, that passes completely through the body *without having at any part any direct communication with the interior*. When any communication does occur, as in disease (typhoid fever, etc.), death probably ensues. This tube commences at the mouth and terminates at the lower part of the bowel (the anus), and, in man, is nearly 30 ft. long. The digestive tube is sub-divided into four parts—the mouth, œsophagus, stomach, and intestines. Connected with it are two large digestive glands—the liver and the pancreas.



25. ABDOMINAL VISCERA

1, Diaphragm; 2, œsophagus; 3, stomach (*a*, cardiac end; *b*, fundus; *c*, pyloric end); 4, duodenum (*d*, opening of the pancreatic and the common bile duct); 5, jejunum and ileum; 6, large intestine (*e*, cæcum; *f*, cæcal appendix; *g*, ascending colon; *h*, transverse colon; *i*, descending colon; *k*, sigmoid flexure; *l*, rectum); 7, spleen; 8, liver, showing the under surface (*m*, gall-bladder; *n*, hepatic duct); 9, pancreas; 10, right kidney; 11, left kidney

The Teeth. The first part of the digestive apparatus that we encounter in the mouth is the teeth. The teeth should be 32 in number in the adult, and 20 in the child; but, as a rule, there are some missing. The approximate date when each tooth appears is marked in the diagram [26]—in *years* on the upper or permanent teeth, and in *months* on the lower or milk teeth. As a rule, the teeth in the lower jaw are cut before the corresponding teeth in the upper jaw. It will be seen from the diagram that the 12 extra teeth in the adult are all molars, room for which is found by the greater size of the jaw. The two *bicuspids* in the adult take the place of the two molars in the child. At birth the germs of the milk teeth and the permanent set are in the head, and at six years of age, when the first molars of the second set have appeared, and before any of the milk teeth are lost, all the teeth, except the wisdom teeth, are in the head—48 in number.

A tooth [27] consists of the *crown*, or the visible part; the *fang*, or fangs, or the part buried in the socket (*alveolus*) of the jaw; and the *neck* that unites the two. The main part of the tooth, both crown and fang, is made of dentine, or *ivory*, hollowed in the centre somewhat in the shape of the tooth, and forming the *pulp cavity* in which are situated the blood-vessels and nerves of the tooth. These enter through a small opening at the end of the root, or fang. The dentine is one-fourth animal matter and three-fourths mineral—the one being *gelatine*, the other mainly *phosphate of lime*. It contains a number of minute tubules, many of which communicate with the pulp cavity. On the crown the dentine is covered by a cap of a porcelain-like material called *enamel*. It is the hardest substance in the body, and only contains

about 2 per cent. of animal matter. It is composed of hexagonal rods, and presents in transverse section somewhat the appearance of a honeycomb. The enamel is thickest at the top of the tooth, and gets thinner towards the neck. It is itself covered by a thin horny layer called *Nasmyth's membrane,* familiarly known as the "skin of the teeth," which protects the enamel against the action of acids. In the root, or fang, the dentine is covered with *crusta petrosa*, or common bone, thickest at the end, and, like the enamel, thinning towards the neck.

Varieties in Shape. Teeth are of three principal shapes [**28**]: the *incisors*, or chisel-shaped, for cutting the food; the *canine*, or pointed, for tearing; and the *molars*, for grinding. Such a variety is evidently intended to deal with a mixed diet. The *condyles*, or the pivots of the lower jaw, are also arranged for the same end. In the carnivora, where the teeth are mainly for tearing and the jaw only moves up and down, the condyles are shown as [**29**] *transverse*. In the rodentia, where the teeth are for cutting, the condyle is *antero-posterior*, allowing of a backward and forward movement of the jaw. In the ruminants, where the teeth are mainly for grinding, the condyle is *circular*, allowing of a rotatory motion; while in man it is *oblique* and *partly circular*, allowing of a combination of all these different motions. The lower jaw has a *double joint*, a pad of fibro-cartilage being interposed for the double object of deadening the sound when chewing (the jaw being close to the ear), and of diminishing the risk of dislocation, while allowing of the freest movements. When the jaw is open, the lower teeth are in advance of the upper; when shut, the upper are in advance of the lower.

What Mastication Is. The action of mastication, like so many others in the body, is partly unconscious and partly under the control of our own will. The process of mastication consists of a combination of tearing, cutting, and grinding the food into a pulp by means of the teeth, assisted by the tongue and the rotatory movement of the jaw.

The second part of the process of mouth digestion is that of *insalivation* of the food, by which means it is all uniformly moistened, alone enabling dry food—such as biscuits—to be eaten at all, and by which the *starchy food is changed into sugar*. *Saliva* is a transparent, watery, slightly viscid alkaline fluid, with a specific gravity of 1005, and of the following composition:

Proteid	2 per cent.
Salts..	2 per cent.
Water	95 per cent.
Ptyalin	1 per cent.

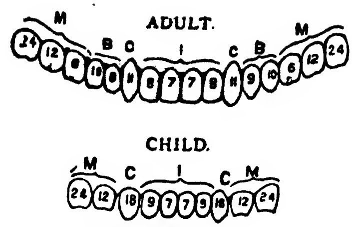
It is manufactured at the rate of about a quart a day, and has several purposes. It moistens the mouth and tongue and food so as to be conveniently swallowed. Mastication mixes the food with it. Its chief value lies, of course, in the ferment—*ptyalin*—which it contains, the full virtues of which will be explained subsequently.

The saliva is formed in three pairs of glands. One pair, the *parotid glands*, are situated in the cheeks, and open into the mouth by a small duct (Steno's) at the back of the second molar tooth on each side. These glands secrete a clear limpid saliva free from mucin [**30**]. The other two pairs are the *sublingual* and the *submaxillary*. The former are beneath the tongue, and open with the former by common ducts (*Wharton's*). The saliva from these is more viscid, and contains much mucin. The flow is checked by nervous influences, such as terror. The ordeal of rice, practised in India, is based on this fact. If the man can swallow the dry rice—which is very possible by the aid of saliva—he is pronounced innocent; if he cannot—the flow of saliva being checked by fear—he is pronounced guilty. It is also inhibited by certain drugs such as tannic acid, and is excited by other drugs, such as pellitory root. Hence, sipping tea at meals checks the digestive process here, and also in the stomach. The flow of the parotid gland (from its position) is specially stimulated by the act of mastication.

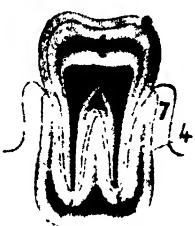
The Throat. The throat, or *pharynx*, is divided from the mouth proper by the two *tonsils* at the sides, and the *soft palate* above, which hangs down like a curtain with a prolongation called the uvula in the middle [**31**] The pharynx contains *seven openings*: two in the floor—the anterior, the *larynx*, leading to the lungs; the posterior, the *œsophagus* or *gullet*, leading to the stomach. Above are the two posterior *nares*, or nostrils, the usual seat of growths in children, called adenoids; while on each side are the openings of the two *eustachian* tubes that carry air to the middle ear. The seventh is the *mouth*, in front.

The tonsils are masses of lymphatic tissue of those white corpuscles that war on bacteria. They contain numerous crypts or holes (some 10 or 12 in each), at the bottom of which glands open that secrete a tenacious mucus which coats the "bolus" of food as it passes between them. The researches of Metschnikoff and others lead us to think that they, in common with similar groups of cells in the intestines, may be the seat of active combats between invading bacteria and the defending leucocytes with which they are filled.

Nature's Device. The whole of the upper part of the pharynx and neighbouring passages are lined with columnar ciliated epithelia, which present an amazing appearance. This form of cell has on its surface several hairs. These, closely set together and covering the whole of the pharynx behind the tonsils, give the appearance of a rich velvet pile. But as these hairs are never still, but are incessantly lashing towards the mouth several times a minute, they present rather more the appearance of a field of corn swayed by the wind. They do not wave to and fro, but *lash* in a special direction all through life, day and night without ceasing. Those in the lower tubes lash upward, the upper ones downward, the side ones forward, and pass all particles or accumulations of all sorts into the mouth, and so get rid of them. This is one of the most beautiful and useful devices of Nature. The œsophagus, or gullet, is the narrowest and

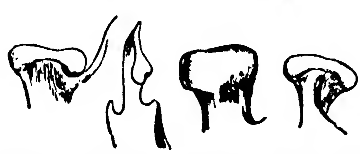


26. THE TEETH
The upper row are the permanent teeth, the lower row being the milk teeth
M, molars. B, bicuspids. C, canine. I, incisors

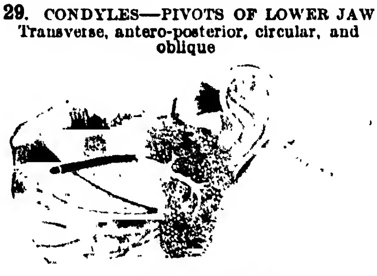


27. VERTICAL SECTION THROUGH A TOOTH
1, Dentine; 2, enamel; 3, pulp cavity; 4, crusta petrosa; 5, blood-vessel and nerve; 6, maxillary bone; 7, gum

28. SHAPES OF THE TEETH
1, 2, Incisors; 3, canine; 4, 5, bicuspids; 6, 7, molars; *a*, crown; *b*, neck; *c*, fang



29. CONDYLES—PIVOTS OF LOWER JAW
Transverse, antero-posterior, circular, and oblique



30. PAROTID GLAND DISSECTED; SHOWING THE CELLS SOMEWHAT ENLARGED
1, Parotid gland; 2, Socia parotidis; 3, Stenson's duct; 4, opening of Stenson's duct upon the inner surface of cheek; 5, gland substance; 6, masseter muscle

strongest part of the alimentary canal. It is a tube nine inches long, reaching from the throat to the stomach.

How Food Descends. The passage of the food, liquid or solid, down the gullet is *never by gravity*, but is always a muscular act, excited by the food stretching the tube. The peculiar motion of smooth muscular fibre is called *peristaltic*, and is in a succession of waves, spreading from above downwards, thus gradually pushing the food either downhill, or as in horses drinking from a stream, uphill into the stomach.

The *stomach* [32] is a bag about 10 in. long, 4 in. broad, and 4 in. deep—but varying greatly in size according to the food it contains—lying transversely across the body from left to right, behind and below the end of the *sternum*, or breastbone. It is separated from the lungs and heart in the *thorax* above by the *diaphragm;* but the heart especially may, when it is distended, be said almost to rest upon it.

The Stomach. The shape of the human stomach is similar to the "bag" in the bagpipes, which is formed from that of a cow. The proximity of the heart to the stomach explains the phenomena of palpitation in case of stomach distension, and is well illustrated by the case of a man who died from a thorn he had swallowed into his stomach penetrating into the heart. The stomach is simply a distension of the general intestinal canal for a special purpose. Ruminants have altogether four stomachs, for the long processes of digesting raw vegetable food. Birds, being destitute of teeth, have stomachs with surfaces so hard that they grind the food there, instead of in the mouth. These are called gizzards.

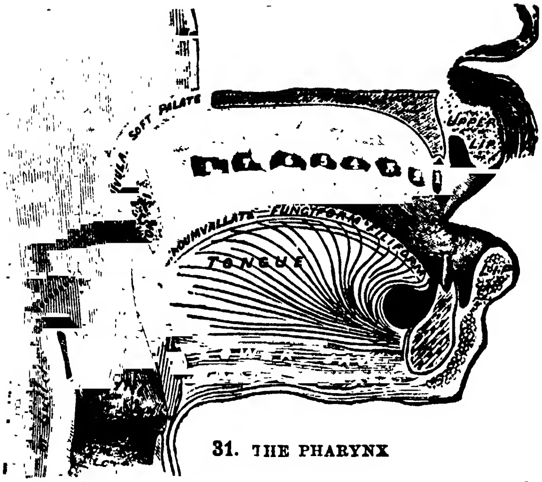
The gullet, or œsophagus, enters at the upper surface of the stomach, about 3 in. from the left or cardiac end. The opening into the bowel, called the *pylorus*, is at the extreme right end. The lower sweep from the gullet round to the pylorus is called the *greater curvature*, while the upper sweep above is called the *lesser curvature* of the stomach. The stomach secretes a ferment called pepsin. The whole of the stomach is lined with fine tubular glands [33], which secrete from the blood a fluid called the gastric juice, at the rate of about a gallon a day. This contains the ferment and also free hydrochloric acid. Its rough analysis is as follows:

Water	99·3
Pepsin	·3
Hydrochloric acid ..	·2

The smell or sight or thought of food causes this straw-coloured fluid to ooze out into the stomach, so that by the time the food arrives below there is sufficient always ready to begin operations at once. These consist in more fluid being poured forth, and the stomach commencing to move violently like a churn, the motion being kept up for hours. Now, here, again, is a wonderful thing — that such a violent motion can take place inside us of which, as a rule, we are wholly unconscious.

The Intestines. The *intestinal* part [25] of the alimentary tube in man is 27 ft. long, the *small intestine* being 21 ft. and the *large* one 6 ft. Its length in different animals is dependent on the food they take. It is shortest in carnivora, where digestion is quickest, and longest in the herbivora, where digestion is slowest, as in the sheep, where it is about thirty times the length of the body, as against ten times the length in man (measured from the vertex to the buttock). In carnivora, such as the dog where digestion is quick, it is about three.

The *small intestine* in human beings is a tube about 1 in. in diameter, beginning at the pyloric valve, and forming a convoluted mass in the centre of the abdomen, and terminating at the *ileo-cæcal* valve, where it



31. THE PHARYNX

enters the large intestine, or colon, a little above the right groin, just by the appendix. It is divided into three parts. First, next the stomach, the *duodenum,* which is the shortest and widest, and is so called because it measures the breadth of 12 fingers (about 1 ft. long). This curves like a horseshoe round the head of the digestive gland called the *pancreas.* A double tube opens into it here, conveying the bile from the liver and the pancreatic juice. Next, the *jejunum,* about 8 ft. long, so called because after death it is generally *empty*; and, lastly, the *ileum,* about 12 ft. long. The upper part of this intestine, and particularly the duodenum, is full of glands, and of elevations called *villi;* also of collections of white cells called *Peyer's patches.*

32. STOMACH AND DUODENUM

a, Œsophagus, lower part; *b*, lesser curvature; *c*, greater curvature (an artery running along it); *d*, fundus; *e*, anterior wall; *f*, pylorus (transition between stomach and intestine); *g*, duodenum; *g'*, first portion; *g''*, descending portion; *g'''*, transverse portion; *h*, beginning of jejunum; *i*, common bile duct; *k*, pancreatic duct. The two latter unite before their entrance into the duodenum

The *colon,* or large intestine, is about 2 in. in diameter, and may also be divided into three parts—the *ascending, transverse, and descending.* The first part begins at "Appendicitis Corner," with a blind extremity where the appendix is attached, and runs straight up the right side to the lower border of the ribs. The *second* passes across from right to left just below the ribs; and the *third* part descends from the left ribs to the termination of the canal. As it descends it bends into a large double curve like an S, called the *sigmoid flexure,* and thence becomes straight (called the *rectum*), ending at the *anus.*

Intestinal Valves. These are five in number. The *pylorus* is a muscular ring capable of closing the exit from the stomach. The *ileo-cœcal* valve is the second, where the ileum joins the colon, and has two flaps that allow passage into the large intestine, but none backwards. The third is a circular muscular construction at the commencement of the rectum that prevents the entrance of the intestinal contents into it, except at times. The fourth is the *internal sphincter,* and the fifth the *external sphincter* of the anus, at the termination of the canal, both being firm muscular rings. The latter has striped muscle fibre, and is thus under voluntary contro

The whole of this digestive tract—at any rate, from the throat to just above its termination at the anus—consists, as we have seen, of a tube of various sizes and shapes, lined with a special mucous membrane full of glands secreting digestive fluids of various sorts and elevations like the fingers of gloves, called villi [34], and made of muscular walls that are completely under the control of the unconscious mind. The muscle is what is called unstriped (save just at the anus, which is under conscious control), and moves in a peristaltic or vermicular or worm-like manner. It does not contract as a whole, but the contractions spread in waves from fibre to fibre, gradually forcing the contents onwards.

Digestive Fluids. The *pancreatic juice* is a product of a gland called the pancreas, or in animals the

33. TRANSVERSE SECTION THROUGH THE WALL OF THE STOMACH

1, Longitudinal plain muscular fibres; 2, transverse plain muscular fibres; 3, peptic glands; 4, peptic glands showing the central cells; 5, peptic glands showing the arrangements of the blood-vessels; 6, openings of the peptic glands upon the inner surface of the gastric mucous membrane

sweetbread [35], lying across the body, from right to left, behind the stomach, its head surrounded by the duodenum, and lying against the liver on the one side, and the tail touching the spleen on the other. It is somewhat the shape of a hammer, with the handle coming to a point. It is from 6 to 8 in. long, and about $1\frac{1}{2}$ in. broad and thick, and weighs nearly a quarter of a pound.

The pancreatic juice itself is a clear, viscid, strongly alkaline fluid, very like saliva, sp. gr. 1015, secreted at the rate of *three-quarters of a pint in the day*. It is the most powerful digestive fluid in the body.

34. TRANSVERSE SECTION THROUGH THE SMALL INTESTINE
1, Serous or peritoneal coat; 2, inner longitudinal coat; 3, inner circular coat; 4, 5, muscularis mucosæ; 6, submucous coat; 7, intestinal villi, with the epithelial lining; 8, arrangements of the blood-vessels of the villi; 9, network of lymphatics in the submucosa; 10, villi with central chyle-vessels; 11, nerves of the submucous and muscular coats; 12, crypts of Lieberkuhn; 13, lymph follicle; 14, lymphatic vessel

The *bile* is the second digestive fluid in the intestines, and is a secretion formed by the liver. It enters the *duodenum* by the same opening as the pancreatic juice, down the common bile duct, at the rate of a *quart a day*. It is a somewhat viscid fluid, of a golden-yellow colour, bitter taste, slight alkaline reaction, and with a sp. gr. of 1020.

The liver [25] is a large organ behind the lower ribs on the right hand side of the body, has five letters, five lobes, five ligaments, five fissures, five vessels, five functions, and weighs 50 oz. It is situated partly under cover of the ribs on the right side of the body, just beneath the diaphragm, and consists essentially of a mass of *hepatic* or modified epithelial cells, divided into clumps called *lobules* (one-twentieth of an inch in diameter), not visible to the naked eye, separated from each other by fine fibrous tissue, with which the whole organ is invested, and by blood-vessels.

35. THE PANCREAS
1, 2, Tail and head of the pancreas; 3, pancreatic duct (canal of Wirsung); 4, supplementary pancreatic duct; 5, opening of pancreatic duct; 6, opening of common bile duct

Circulation. The circulation of the blood is maintained by special means. The heart is not sufficiently powerful to drive the blood through two sets of capillaries—those in the alimentary canal and those in the liver; hence the veins in the liver are not collapsible, but always open, and every movement of the intestine drives the blood forward by the collapsing of the abdominal and portal veins, into the open veins of the liver. It is then sucked up into the thorax at every inspiration, through the greatly diminished pressure there and thus reaches the heart through the ever-open hollow vein called the *inferior vena cava*.

The *formation of bile* is *one* of the chief functions of the liver cells. As produced, it is passed into the tiny ducts that lie between the opposing surfaces of the cells, and then passes out of the liver to be stored in a special receptacle called the *gall-bladder*, which is a strong bag about 4 in. long, able to hold about 1 oz. of bile. If digestion is going on at the time, the secretion becomes more active, and the bile, instead of entering the gall-bladder, passes straight down into the duodenum. The properties and uses of bile have been already described.

The *formation of glycogen*, or *animal starch*, is the *second* chief function of the liver. It is a substance *isomeric* with, or having the same formula, as starch, and colours red with iodine. The molecule of water added by the ptyalin, which changes starch into malt sugar, is here removed, thus converting it into glycogen. It is readily changed back as required into sugar by a ferment present in the liver.

The *third* chief function of the liver is the purification of the products of digestion from self-made poisons. If for any reason this fails to be perfectly done, a bilious attack is the probable result.

To be continued

SILK AND THE SILKWORM

The Cultivation of the Worm. Raw Silk. Silk Reeling. The Utilisation of Silk Waste. The British Silk Trade

By W. S. MURPHY

SILK is the finest of textile yarns, the most beautiful of woven fabrics. The choice garment of beauty, the flowing robe of regal dignity, the vestment of priestly office—silk is the poetry of the textile world. It enriches and adorns every other fabric. The noblest of fibres, it is worthy of noble use.

The manufacture of silk did not become an industry in our own country until late in the sixteenth century, and here, as elsewhere, it was religious persecution in Continental Europe that planted the seeds of what became an important trade. At first British silk weavers depended on Continental "throwers" for yarn, but in 1718 a silk-throwing establishment was started in Derby. The process of utilising silk waste introduced by Samuel Cunliffe Lister, of Manningham, marked an epoch in the English silk trade. But the silk industry has declined from the middle of last century, and from being responsible for the employment of nearly 150,000 employés it has shrunk until now only about one-fourth of that number find in it the means of subsistence.

Centres of the British Silk Industry. The principal centres of silk manufacture in Great Britain at the opening of the twentieth century were as follow:

CONGLETON. The abandonment of Protection probably hit Congleton harder than any town in England. Up till 1858 silk-throwing was the principal industry, employing over 5,000 people. In 1859 there were forty mills in the district, and the number had dwindled down to six in 1890. The trade, however, has not quite lost its vitality, and shares in the present moderate prosperity of the silk industry, producing yarns, ribbons, trimmings, crapes, bindings, and gauzes.

COVENTRY. For over 200 years silk ribbons have been made in Coventry, and ribbon manufacture is still a staple industry of the town. Latterly, however, the silk weavers of Coventry have taken up other branches of the trade, and now produce a wide variety of stuff such as plaids, ottomans, failles, plush shades, brocade neckties, chenille, and other trimmings.

DERBY. Though the first silk-throwing mill in this country was built there, the silk trade of Derby has never been of very great importance. Trimmings, surgical bandages, silk stockings, and silk yarns are the chief products.

LEEK. This town very probably owes its silk industry to the charity which the Vicar of Leek extended to French Protestant refugees fleeing from persecution. The history of Leek silk trade is a record of almost continuous progress. Beginning with button-making, Leek manufacturers proceeded to take up ribbons, brocades, serges, handkerchiefs, damasks, and sewing silks, the last mentioned being at present the chief output. Over fifty firms are engaged in silk manufacture in the district. Silk-dyeing is also very important in Leek.

LONDON. Spitalfields silk industry began in 1563. Small at first, the trade received large and powerful impulse from the Dutch refugees in 1585. The product of this industry has changed several times during the 300 years of its existence. Originally, silk stockings, vestings, and garment goods, plain and figured, were woven in Spitalfields, but at the present day the looms are employed upon plain and figured silk, and velvet for furniture, scarfs and ties, umbrella and sunshade coverings, chenille and trimmings. Lately, the dress goods trade has been revived.

MACCLESFIELD. A silk-throwing mill was established here in 1756 by Mr. Charles Roe, and the industry prospered so long as it was exempt from foreign competition, but in recent years it has greatly declined. Macclesfield weavers, however, are still famous for ladies' neckties, sarcenets, bandanas, and handkerchiefs, and have lately entered into a close competition with the silk cloth manufacturers of the Continent, in which they are holding their own.

MANCHESTER DISTRICT. Early in the nineteenth century silk manufacture was set up as a rival to cotton in the Manchester district, but the competition was almost fatal to the finer industry. Cotton swept all before it, silk only surviving in the outlying parts, as Patricroft, Leigh, Middleton, and West Houghton were then. In these places a fair amount of weaving is still done, the products being piece goods, galloons, and small wares.

NORWICH. In 1564 Queen Elizabeth granted, at the instance of the Duke of Norfolk, licence to 300 Dutch and Walloon refugees to carry on the industry. Since that date silk manufacture has continued in Norwich, the trade now consisting of crapes and spun silks, chiefly decorative furniture cloths.

YORKSHIRE. The silk trade of Yorkshire is confined almost wholly to spun silk. The waste from silk-throwing, spinning, and weaving, and the broken cocoons, is put through machinery similar to that employed in making worsted yarns, and woven into plushes, velvets, and plush goods. Bradford and Halifax are the principal centres of this industry.

Signs are not wanting that, after many ups and downs, the silk trade of this country has entered on an era of progressive prosperity. By the adoption of the best French and Italian practice, and by technical education, the silk

industry of Great Britain is steadily developing, and the future is full of promise.

Silkworm Cultivation. Silk manufacture originated in China. According to Chinese tradition, the Emperor Foh-hi, about 5000 B.C., taught his people how to cultivate the silkworm. During the reign of Hoang-Ti, 2600 B.C., his empress See-Ling-Chi invented the cocoon-reeling mill [13] and the weaving loom.

For thousands of years the Chinese jealously guarded the silkworm from the knowledge of the outer world, but the culture of the silkworm spread west, through Bokhara, Khiva, and Samarcand, to Teheran, and became an established industry of Persia.

Spreading by land, the knowledge of silk also diffused itself by sea. The Phœnician traders brought silks from China, both yarns and cloths, and distributed them over the Western world at least 1,000 years before the Christian era.

Silkworm rearing was the monopoly of the Emperor at Constantinople for a considerable time; but gradually the culture extended south to the Levant, and silkworm gardens became common in the south of Greece.

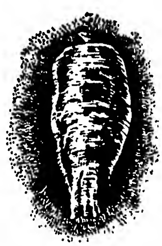
Silk in Western Europe. Spain was the first country of Western Europe to receive the silkworm, the Arab conquerors introducing it there about the tenth century, probably from their homes on the borders of Persia. When the Moors took over their Spanish dominions from the Arab caliphs they greatly extended the industry, and silk factories were established at Seville and Grenada in the thirteenth century.

Roger, the Norman King of Sicily, invaded Greece, took captive a number of Corinthian weavers, and settled them in Palermo, at the same time importing the mulberry and the silkworm. This was in 1147; and in a few years silk culture spread to Calabria, and thence into Italy, where an important silk industry grew up within a century. Lucca was an important centre of the industry in 1248, but civil wars being of frequent occurrence in that town, the authorities of Milan, Florence, Bologna, Venice, and Genoa offered asylum to the silkworkers. It would seem that the invitations were accepted, for the silk industry was established in all these places before the middle of the fourteenth century.

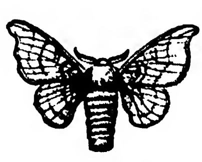
In 1516, when Francis I. of France had obtained possession of Milan, he settled some of the Milanese silk producers at Tours, and laid the foundations of the French silk industry. We must remember, however, that the mulberry trees planted by Pope Clement two centuries before had their effect in fostering silkworm culture in the valley of the Rhone, affording the weavers of Lyons the plentiful supply of raw material of which they have made such splendid use.

8. THE CATERPILLAR

9. THE COCOON



10. THE COCOON BREAKING



11. THE MALE MOTH

12. THE FEMALE MOTH

LIFE HISTORY OF THE SILKWORM

Silkworm cultivation has been tried in England at intervals during the past three centuries. The most notable experiment was that of the British, Irish, and Colonial Silk Company, started with a capital of one million sterling in 1825. No result came from the experiment. So far as our knowledge goes, the many later attempts have also resulted in failure as commercial ventures. Climatic and other conditions in this country seem to operate against the success of silkworm cultivation.

Cultivation of Silk in United States. The vast territory of the United States seems to offer a wide and suitable field for silkworm cultivation, but hitherto all the efforts of the Americans have failed. In 1660 a man named Aspinwall planted mulberry trees on Long Island with a view to silk culture. The industry seems to have taken some slight root, and a century later the British Government offered bounties amounting to 25 per cent. on the value of all raw silk exported from the colonies to Great Britain. The War of Independence put an end to the arrangement. In 1831 a determined effort was made to establish silk culture in the United States, and some success was attained in both Connecticut and Massachusetts; but speculators created a mania, known as the "Horus multicaulis craze," and the financial disasters ensuing overwhelmed the industry.

The same story was repeated in 1861, when M. Prevost, a French enthusiast, instituted silkworm culture in California. In 1878 Professor Riley, entomologist of the United States Department of Agriculture, aroused renewed interest in the subject. In the following year the department began a series of experiments which continued over 10 years, seeming, to observers

at the time, to exhaust every expedient in the effort to make the industry commercially successful. After an interval of 10 years the Department of Agriculture determined to renew its efforts, and in 1902 experiments were begun.

It would seem that the chief obstacles to the success of silkworm cultivation in the United States are the high cost of labour and the comparative profitableness of agriculture and other manufacturing industries. In some of our Imperial dominions those two obstacles are almost wholly absent, and the prevailing climatic conditions more nearly resemble those of the countries in which the silkworm is native.

At the International Exhibition 1873, cocoons produced in the colonies of New Zealand, New South Wales, Queensland, and Cape Colony were shown; but up to the present raw silk does not appear among the exports of these colonies.

Rearing the Silkworm. All silkworms are moth caterpillars [8], and the varieties are very numerous. Caterpillars, it is well known, feed on vegetable leaves. The favourite food of the common silkworm, *Bombyx mori*, is the white mulberry leaf. Cultivated mulberry trees are propagated by grafting cultured shoots on wild stems. The wood should be carefully pruned to promote leafage. In China the bushes are never allowed to grow taller than 6ft. Left free to grow, the mulberry attains a height of 50 ft.

Other caterpillars are not so particular in their choice of food as the *Bombyx mori*, and silk cultivators have found it profitable to breed some of the other varieties. Small as the silkworm appears, this question of food is a very serious one, a single ounce of eggs producing worms which consume during the period of development no less than 1,500lb. of mulberry leaves. In the table following we give the leading varieties of silkworms, with the foods on which they can be reared.

Species.	Foods.	Where cultivated.
Bombyx Mori	White Mulberry	China, India, Japan, Persia, Turkey, Greece, France, Italy, Spain.
Cynthia	Ailanthus.	China, India, Japan, France, Italy.
„ Pernyi	Oak	Newchang (China), India.
„ Mylitta	Oak	North China.
Attacus Atlas ..	Omniverous	China, Burmah, India, Ceylon, Java.
Cynthus	Ailanthus..	India, France, Italy, America, Java, Nepaul.
„ Ricini ..	Castor-oil Plants	Assam, India, Cachar.
Antheraa Paphia (Mylatta) (Tussih moth)	Ber, and various Indian shrubs	Over all India, and lately introduced in Europe.
Antherea, Mazankoong	Oaks	Assam.
„ Assama	Laurus obtusifolia	Assam.
Actias Selene ..	Various wild fruit trees ..	Mussooree, Sikkim, Madras.
Yama-mai.. ..	Wild Oak.. ..	Japan, Italy, France, America.

Food and Treatment. The moth of the common silkworm is about 1in. long, the female [12] slightly larger than the male [11]. The insect has a thick, hairy body, short head, and broad wings of whitish grey, barred with pale brown, resting convexly over the body. After the pair have lived four or five days, the female lays her progeny of 500 eggs, and the parents die. The microscopic globules have been deposited with a soft, gummy substance, which, if allowed to dry, forms a silky coating; but that must be prevented. As soon as the eggs have been laid, the silk cultivator washes them, and provides for them a clean tray on which to begin life. Here the eggs are kept in a warm temperature till hatched, when the worms emerge a little over one-twelfth of an inch long. For a period of four days the little things wriggle about, and then become torpid and sick. The first skin has hardened, and will not admit of further growth. On the fifth day the skin breaks at the neck, and the caterpillar, by wriggling and writhing, frees itself from the old skin and reappears in a new dress, very lively and ravenously hungry. Food must be given sparingly at this state, but at regular intervals. In three days the moulting process begins again, and on the fourth day the caterpillar assumes its second dress. This skin lasts about five days, and is cast off as before. A fourth, and in some cases a fifth, skin is assumed, and then the worm, having attained a length of 3½ in., ceases to feed, and seeks a suitable place in which to begin its spinning. In China, India, Japan, and other countries, sub-tropical and tropical, the silkworm is allowed to mount on bushes in the open air, but the European cultivator requires to provide nests for the operation of cocoon-spinning. Some simply supply little bunches of twigs, others make small paper cones, and allow the silkworms to use them as they please; but the Italians have devised little box trays formed by slips of wood, which seem to answer the purpose very well.

Some Rules. Before leaving this subject, we would repeat the advice which experienced silkworm-rearers have given to those who would be successful in the industry.

Feeding. Clean, dry, wholesome food is essential. Spotted, worm-eaten, or mildewed leaves are injurious to the caterpillars. Feed sparingly during the time they are casting their skins. Supply the full-grown worms with as much food as possible.

Warmth and Light. Keep the eggs in an even temperature of not more than 64° F. Avoid hot sun, and give plenty of light. After hatching raise the temperature gradually to about 82° F. till the worms have cast their skins, when the temperature should be lowered and gradually raised again. Avoid draughts and sudden variations in temperature.

General Influences. Loud noises of any kind are apt to induce disease in the silkworms. Smells, agreeable or otherwise, exercise a disturbing effect, and should be avoided. Smoke is another nuisance much dreaded by the experienced silk cultivator.

Gathering the Silk. Let us examine the full-grown silkworm. On the underside of the yellowish-grey body two intestine-like tubes are visible, extending from the tail to the mouth, on the upper lip of which is a curious little point called a spinneret. The tubes are full, and stand out in the body. The head moves about, and gradually a coarse, silky substance appears and winds round the body. This is the floss which forms the outer coating of the cocoon [9 and 14]. Drawing itself in, the silkworm goes on spinning, filling out the floss as round after round of silk winds on its body. Within five or six days the spinning is done, and a cocoon the size of a pigeon's egg formed. Our silkworm has spun a length of from 600 to 1,000 yards of silk, though of that amount we may not be able to reel more than 300 to 500 yards.

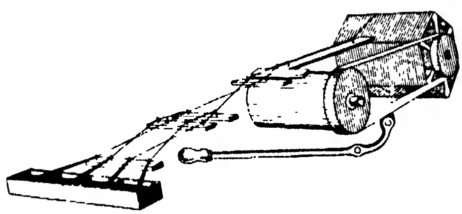
Stifling. Nature does not intend that the cocoons should be unwound. Left to itself, the worm grows into a moth, emerging through the broken cocoon [10], and the silk is "cast as rubbish to the void." If the silk is to be preserved, the worm must be killed. Various methods are adopted for choking or stifling the silkworms. The oldest practice was to subject the chrysalids to intense, dry heat in a closed oven. More scientific and certain in its effects is the application of dry steam, first devised by Professor Gastrogiovanni, of Turin. For this process the utensils are very simple. A basin with a furnace underneath, movable frames for the cocoons, trays, and a bell-receiver comprise the principal parts of the plant. Enough water is put into the basin, which is heated to 100° C., the bell cover is lifted, and the tray of cocoons inserted. In 15 minutes the intense heat has killed the caterpillars and preserved the thread.

Reeling the Cocoons. Empress See-Ling-Chi's invention [13] gave the principle of silk reeling to all subsequent machines. As shown in ancient Chinese prints, the reeler consisted of a small tray, five slips of lancewood, a small cylinder, and a hexagonal reel. Stripped of floss, the cocoons are put into the tray, which has been filled with warm water. With a whisk, or branching twig, we work on the cocoons to get hold of the proper thread. Having caught, say, two filaments, we twist them, and put them into one of the four nicks in the first lancewood slip. We find other two filaments, and place them in nick No. 2. Repeat twice, and fill up the four nicks with strands. Draw out the four strands and cross each pair, passing thread No. 1 into nick No. 2 of the second slip of lancewood, thread No. 3 into nick No. 4, and so on. In the third slip of wood there are only two nicks; into each of these twine two strands. The crossing has made them incline towards each other, and they twine prettily. We now have two strands. Cross the strands midway towards the fourth slip of lancewood, and put them through the nicks. On the fifth slip of wood there is only one nick, and the two strands are converged to it, combined in one smooth, round thread, and wound on to the hexagonal reel at the end of the machine.

In the modern filatures, as the silk-reeling establishments are named, the same process is followed. The cocoon basins are steam-heated, the guides are steel, the motor is the dynamo or the steam-engine, the end reel is large and heavy; but, except in small particulars affecting the speed of the operations, the main lines of the machines were laid down by Empress See-Ling-Chi 4,000 years ago.

Simple as the work appears, the reeler is called upon to exercise skill and care. The object is to produce a thread of uniform weight and thickness. The filaments of the cocoons, however, thin towards the inner rounds. To keep the thread uniform, another filament must be added, and another, sometimes three or four additional cocoons being employed in making up one thread.

Raw Silk. The skein of silk upon the reel is termed *raw* silk, and in that form appears upon the market. From China and Japan the raw silk comes in bales of skeins, weighing on the average 100lb., the skeins varying between 60 and 90 in. in length. French and Italian silks are sold in hanks of about 520 yd., the value being determined by weight.



13. A PRIMITIVE SILK-REELER

It is the ambition of every manufacturer to carry through the process of his trade from beginning to end. The reeling described is seldom combined by British workers with silk-throwing—that is, the making of silk yarns—and never with silk manufacture. About 1850 a process was patented in this country by which silk manufacture could be started with the cocoons. Mr. B. F. Cobb, the first authority of his day, stated in 1877 that this invention had been utilised by a Milan manufacturer; but none of the leading silk firms in Great Britain seem to have adopted it. The process is too elaborate to be given here, but it seems that development in the silk industry lies in its direction.

Spun Silk. No textile fibre produces so much waste in the processes of preparation and manufacture as silk. This is very tantalising, for it is the costliest of all fibres. The flossy covering of the cocoon, though genuine silk, is too coarse, tangled, and full of gum to be unwound, and it is cast out as useless waste. From a fourth to a third of the silk actually upon the cocoon cannot be unwound, and it is cast aside as waste, being called the "knub." To obtain the moths which carry on the race of silkworms we must allow them to burst the cocoons in which they have been imprisoned during the chrysalis state, and there we have more waste. When forming the threads—*filassing*, we name

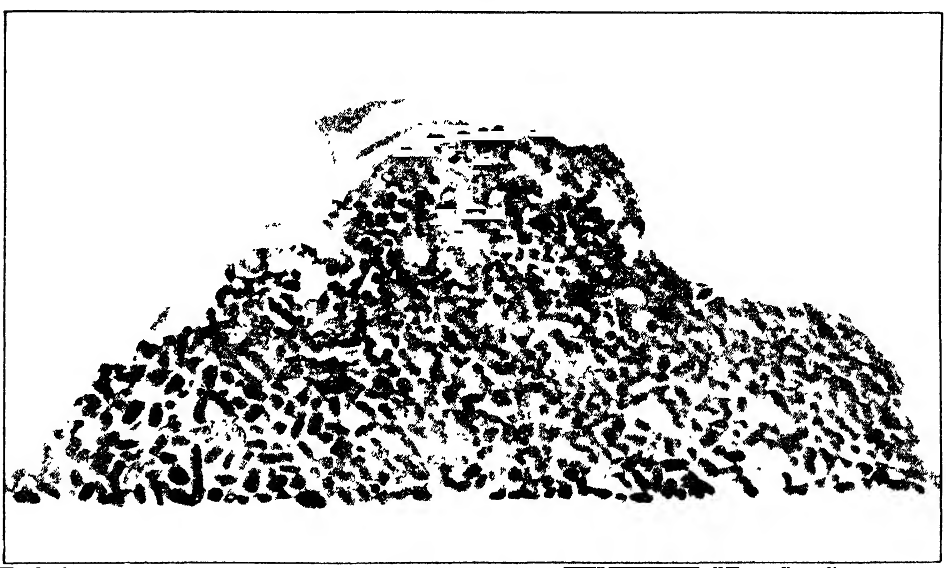
the process—we make waste; and in all the subsequent operations there is waste, though in decreasing proportions. For many centuries the silk manufacturers of Europe especially found the proper disposal of the waste a very serious problem. With the increasing growth of towns, and the restrictions imposed by sanitary authorities, the problem became even more insistent. Incredible as it may seem, our beautiful and costly fibre, the most precious of textile materials, was, in its waste state, denied even the refuge of the manure heap. It was rejected as a field manure because it would not rot.

Utilisation of Silk Waste. Like most industrial changes, the utilisation of silk waste was a gradual growth. The waste from the throwing-mills and weaving factories was gathered and put through the same process as shoddy rags, quite unobtrusively, and merely in the ordinary course of trade, about 1830 to 1840. Thus reduced to a proper length of staple, the silk was put through the common process of textile manufacture, being treated in the same way as cotton or wool.

The waste utilised by the process indicated barely touched the great problem. There was a mass of silk waste outside its scope; but the modest beginning gave a hint to a man of genius who was able to take it. Mr. Samuel Cunliffe Lister, afterwards Lord Masham, had his attention called in the year 1857 by a silk broker in London named Spenseley to the immense stocks of Indian silk waste then being accumulated by the city without any prospect of use. Mr. Lister was a partner in a firm of worsted manufacturers, and had acquired some experience in the combing of wools. He examined the stock of silk waste held by Mr. Spenseley. Very unpromising material it seemed, looking, as Mr. Lister afterwards said, more like oakum than silk. He agreed to take a quantity at 1d. per lb., and undertook the experiment. First Mr. Lister boiled a quantity of the waste, and had the satisfaction of seeing the substance which resembled a coagulated mass of mixed gum and rags assume the appearance of a flossy tangle of fibres. From this point the rest seemed easy, and had he been content with inferior results, Mr. Lister would simply have fallen into the ordinary process. But his object was to produce a genuine silk thread resembling in essential character thrown silk. To accomplish this object the firm of Messrs. Lister & Co. expended a quarter of a million sterling in bringing to perfection a dressing machine which would produce a perfectly even sliver—that is, the soft rope from which the thread is drawn and spun. Upon the quality of the sliver depends in large measure the character of the yarn subsequently produced. This is specially true of silk, for the microscopic filaments obstinately retain little knots and irregularities which reveal themselves when the thread has been spun.

The spun-silk trade, as developed by Messrs. Lister & Co., made a link of connection between the silk and wool and cotton industries, with the result that silk manufacture was taken up in such cotton-spinning centres as Rochdale and Oldham, and in the wool manufacturing towns of Yorkshire

To be continued



14. SILK COCOONS

Continued from page 420

SHORTHAND

Fourth Instalment of the Special Course of Shorthand Taught by Messrs. Pitman and Sons on their Twentieth Century Plan

By Sir ISAAC PITMAN AND SONS

THE liquids *l* and *r* are often found following and closely united or blended with other consonants, forming a double consonant or consonantal diphthong; as in the words *pl*ough, *br*ow, *gl*are, *dr*ink, *fl*y, *fr*y, ma*ker*, dou*ble*, etc. In pronouncing these words, the combination of the *l* or *r* with the preceding consonant is uttered by a single effort of the organs of speech. These consonant combinations are represented by adding an initial hook to the simple characters to indicate their union with a following *l* or *r*.

Initial Hook adding L and R to Straight Letters. A small initial hook written *towards the* LEFT, adds *L* to straight consonants, thus

p, *pl*, *bl*, *tl*, *dl*, *kl*, *gl*.

A small initial hook written *towards the* RIGHT, adds *R* to straight consonants, thus

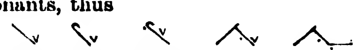
p, *pr*, *br*, *tr*, *dr*, *kr*, *gr*.

The following mnemonic aid will be useful for remembering the *pl* and *pr* series. If the *L*eft hand be held up, with the first finger bent, the outline of *tl* will be seen; and if the *R*ight hand be held up, in the same way, the outline of *tr* will be seen.

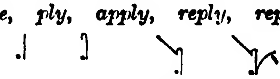
The consonant is not hooked initially, the characters and being employed for *w* and *y*.

The double consonants formed by the initial hooks should be considered as syllables, and named accordingly. Thus should be called *per*, as heard at the end of the word "pa*per*," and not *pee-ar*, which would be written or

Vowels are read before and after these double consonants as they are before or after single consonants, thus



pie, *ply*, *apply*, *reply*, *replica*,



eat, *eater*, *Peter*, *Peterloo*.

The double consonants in the following exercises should be called by their single names, and they will then be easily recognised; thus

per eh (pray).

EXERCISE.

1 

1 Plough, apple, odour, draw, pebble, feeder, rocker.
2 Pickle, globe, shudder, crumble, mocker, archer, track.

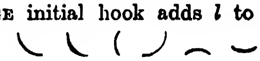
Initial Hook to Curves. An initial hook can only be added to curved consonants in one position, namely, inside the curve, thus The hook, however, may be made either large or small, as in the examples.

The consonants *l*, *r*, and *s* are not hooked to indicate the addition of *l* or *r*. The signs are, therefore, used as extra forms for *fl*, *fr*, and as extra signs for *thl*, *thr*, which with the corresponding heavy consonants, have duplicate forms, thus

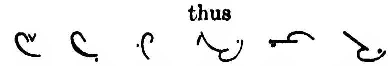
fl, vl, *thl*, thl, fr, vr, *thr*, thr.

L HOOK.

A LARGE initial hook adds *l* to the curves

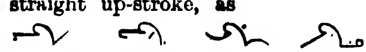


thus



fly, *evil*, *Ethel*, *official*, *camel*, *penal*.

The double consonant *shl* may be written either upward or downward; it is, however, generally written upward. The right curves must only be used AFTER another consonant; they are most conveniently written after *k*, *g*, *n*, or a straight up-stroke, as

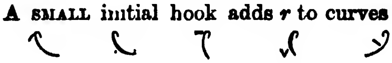


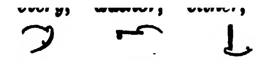
cavalry, *gruffly*, *inflame*, *reflex*;

and after *b*, *l*, as *Bethel*, *lethal*

R HOOK.

A SMALL initial hook adds *r* to curves; thus





measure, *calmer*, *dinner*.

The double consonant *shr* is written downward only.

The alternative forms for *fr*, *vr*, *thr*, are employed as follows:

(a) When not joined to another stroke consonant, the LEFT curves are used when the word begins with a vowel, as

ever, *affray*, *ether*.

(b) The RIGHT curves are used when a vowel does not precede the consonant, as

fray, *three*,

(c) When joined to a stroke consonant which is written *towards the right*, the RIGHT curves should be used whenever possible, as in

throb, *proffer*.

(d) When joined to a stroke consonant written *towards the left*, the LEFT curves should be used whenever possible, as in

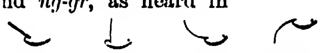
average, *Jeffery*.

(e) But in preference to an awkward joining, either form can be used, as in

Frank, *froth*.

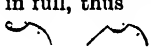
NG HOOKED.

In accordance with rule, the sign would represent the sound *ng-r* as in *singer*. There are, however, so few words in which *ng* is followed by *r*, that this hooked outline is used to represent the frequently occurring sounds of *ng-kr* and *ng-gr*, as heard in

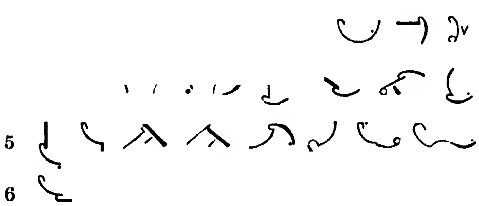


banker, *tinker*, *finger*, *linger*.

Words such as *singer* and *wringer* must, therefore, be written in full, thus

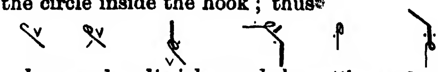


EXERCISE.



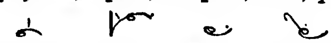
1 ARRival, rival, cavil, flap, muffle, fennel, kennel, shuffle.
2 Ethel, flog, flooR, flurry, ruffle, flinch, gravely, flask.
3 Fever, leather, ARthur, knuckle, freak, friaR, locker.
4 Canker, malinger, adverse, packer, loafer, docker.
5 Fisher, rider, owner, taper, bugleR, treacle, rumour.
6 Dover, river, giver, manner, tether, thrust, **freely**.

Circles and Loops Prefixed to Initial Hooks. The circle *s* is prefixed to straight consonants which are hooked for *l*, and to curves which are hooked for *l* or *r* by writing the circle inside the hook; thus



ply, *supply*, *disciple*, *explode*, *settle*, *pedestal*,

sickle, *physical*, *cipher*, *decipher*, *civil*, *peaceful*,

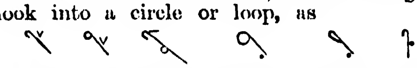


summer, *dulcimer*, *sinner*, *prisoner*.

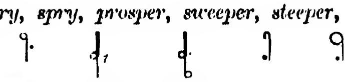
In cases where the hook cannot be clearly shown (which are comparatively few), the separate consonants should be written, as in

forcible, *unsaddle*.

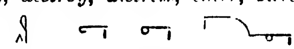
The circles *s* and *sw* and the loop *st* are prefixed to the straight consonants which are hooked for *r*, by writing the circle or loop on the *same side* as the hook, thus turning the hook into a circle or loop, as



pry, *spry*, *prosper*, *sweeper*, *steeper*, *tray*,

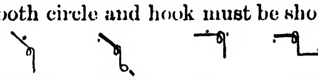


stray, *destroy*, *distress*, *cuter*, *sweeter*,



slouter, *crew*, *screw*, *corkscrew*.

When the circle and hook occur medially *at an angle*, both circle and hook must be shown, thus

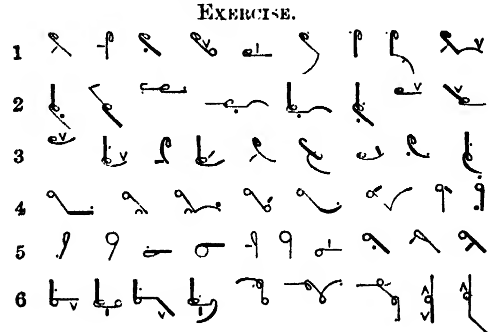


pastry, *abstruse*, *extra*, *gastric*,

The method of writing *skr* and *sgr* after the consonants *t* and *d* is shown in the following examples:

tucker, *tasker*, *degree*, *disagree*.

EXERCISE.



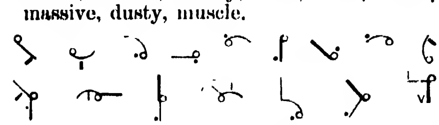
Exercise.

1 **Satchel, sidle, peaceable, exclusive, seclude, tricycle.**
2 **Feasible, noticeable, visible, traceable, plausible.**
3 **Simmer, chastener, listener, passover, lucifer, scrap.**
4 **Spread, jack-screw, stripe, sprung, suitor, stretcher.**
5 **Stater, cider, stalker, stager, stabber, scrub, scrupulous.**
6 **Exeter, lustrous, rostrum, rascal, crusader, decrease.**

Key to Exercises in Last Lesson.

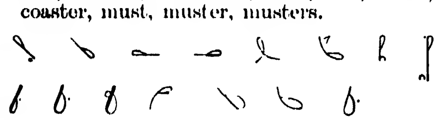
Circle S and Z.

1 Set, siege, soar, cheese, lace, moss, rice, geese, soul, soothe.
2 Chosen, unsafe, musty, cask, desk, razor, massive, dusty, muscle.

1
2


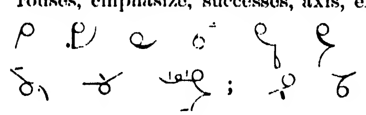
Loop ST and STR.

1 Stud, dust, duster, dusters, stowed, toast, toasts, toaster, steel, least.
2 State, statist, statistics, stiff, fist, coast, coaster, must, muster, musters.

1
2


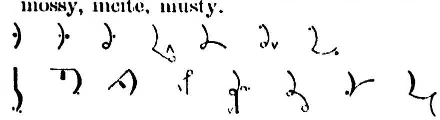
Large Circles SW and SS.

1 Sweat, swathe, swan, swell, swarm, swim, swing, swarthy, swallowing.
2 Successive, necessary, witticism, incisive, rouses, emphasize, successes, axis, excess.

1
2


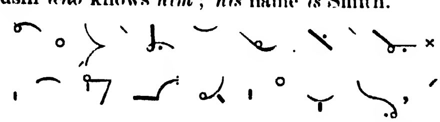
Vowels and S and T.

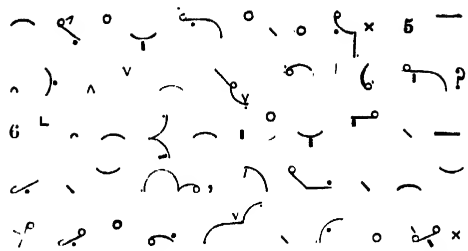
1 Sue, saw, saucy, sauce, saucebox, Esau, asp, see-saw, icy, assessor.
2 Aside, asylum, daisy, disease, Zulu, zinc, mossy, incite, musty.

1
2


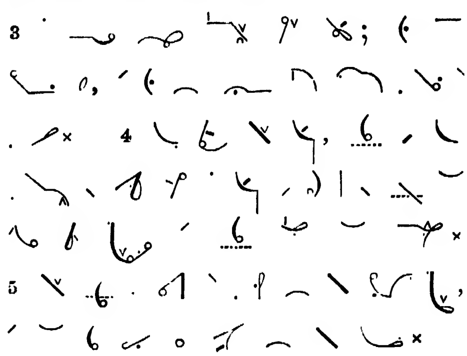
Grammalogues.

3. *The* sailor *is* safe *in the* south, *and can* bask *in the* sun. 4. *The* music *he has given* Miss Rose *is a* song *he* sang *on our* voyages. 5. She *has a* cousin *who* knows *him*; *his* name *is* Smith.

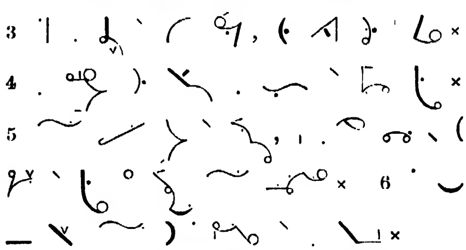
3
4




3. *In his* task *of* tasting, *the* taster's *first* step *was to* burst *the* lid off *a* chest *of the* Chinese tea. 4. *These are* said *to be the* finest we *shall have in* Manchester. 5. *He should put the* teas *in* stock, *and* testify *to those who have* despised *them the* soothing stimulus *these give*.

3


3. *The* Swede *and the* Swiss *think* they *may be first* at *Lord* Ross's party, *and* so they insist *on* sailing *in a* vessel by way *of* Swansea. 4. *This* desire induces *them to* go along at *an* excessive rate.

3
4
5


3. Lucy said they *use an* acid, *as it* easily moves *the* stain *on the* silk. 4. She *can* now *see why it is* Ezra says soda *is of* no *use*.

3
4
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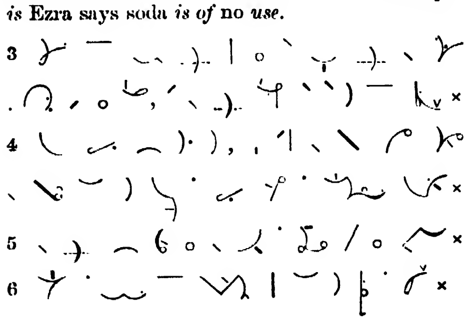


To be continued

Group 1 **AGRICULTURE** **4** Continued from page 434	# FERTILISING THE SOIL **How to Treat Agricultural Soils. Various Kinds of Manure and their Special Uses. The Composition of Artificial Fertilisers**

By Professor JAMES LONG

MOST agricultural soils are well stored with materials which are essential to the growth of plants, but which are in an insoluble condition, and therefore unavailable. These materials dissolve slowly, the necessary change being effected by good cultivation and the introduction of air and warmth which follow it. Artificial, or chemical, manures are employed for the nourishment of plants because, in most cases, the food they contain is readily available. In many otherwise fertile soils one of the three essentials—nitrogen, phosphoric acid, or potash—is temporarily exhausted, the exhaustion of either rendering the soil infertile. If the farmer by simple experiment and careful observation of facts recognises which form of plant-food is needed, he is able to provide it, to restore fertility, and thus practically to command a crop. Although the three fertilising properties named are those which apply to every class of soil, there are occasions on which lime is needed.

Risks in Manuring. It is necessary for the young farmer not only to learn what manures to apply, but what quantities and when. He must, too, avoid the danger of careless mixing, that one form of manure may not destroy the properties of another. He must learn to distribute the manures evenly and in as fine a condition as possible, mixing, if necessary, some dry material, such as ashes or earth, with them for the purpose. Soluble manures, like nitrate of soda, are only used as top-dressings on growing crops, and then only upon the heavier soils. Sown in winter or on light soils, a soluble salt of this character is usually washed into the subsoil or drains, and lost. On the other hand, manures containing potash and phosphoric acid, like bones, dried blood, and other animal fertilisers, are slow-acting and unaffected by rain, in that they are not carried through the soil and wasted. Although there are manures, like the best Peruvian guano, which contain nitrogen, phosphoric acid, and potash, artificial fertilisers are usually classified as nitrogenous, phosphatic, and potassic.

Nitrogenous Manures. The nitrogenous manures include nitrate of soda, a deposit chiefly found in Chili, of which 95 per cent. should be pure nitrate. Nitrate, which contains 15½ per cent. of nitrogen, is highly soluble, and is used for growing crops chiefly on clays and loams. It should be employed only when the soil is in good heart and able to supply other necessary foods, or when those foods are provided in the form of dung or other artificials. Thus, for corn and grass in particular, nitrate is used after a dressing of dung or a phosphatic manure has been supplied, or with mangels which have received dung, or with potatoes which have received a small dressing of dung and supplies of potash and phosphoric acid. It should be remembered that an artificial manure is chiefly employed for the benefit of the growing crop, and this, above all, is the case with nitrate of soda and all highly soluble manures. The old practice of supplying slow-acting manures, such as crushed or ground bones, is uneconomical, good as the ultimate results may be, for money is expended for succeeding crops which may be better and more cheaply fed when the time for their assistance arrives.

Sulphate of Ammonia. This is a by-product in the manufacture of gas, contains about 20 per cent. of nitrogen, and is less soluble than nitrate of soda. It must be converted into a nitrate before it is available to plants. Sulphate can, therefore, be sown with the seed. It should be 95 per cent. pure.

Soot. Whether the produce of wood or coal, soot is valuable for the nitrogen which it contains, and is usually purchasable at 6d. a bushel. Coal soot, however, is much richer than wood soot, although it is now generally superseded by nitrate of soda, on account of the comparative slowness of its action. It is employed as a top-dressing.

Rape-cake. This is the pressed residue of rape-seed from which the oil has been extracted, and, when finely ground, is a useful nitrogenous fertiliser. It is also commonly employed on land which is subjected to wireworm, one of the most destructive of farm pests. The insect is believed to relish the rape, and to prefer it to plants.

Dried blood, horny materials, and woollen waste, all containing nitrogen, are occasionally used in some form for manurial purposes, but are slow acting, and generally uneconomical.

Phosphatic Manures. Bones are one of the chief sources of phosphoric acid, but inasmuch as their gelatine contains nitrogen, and as they are also rich in lime, they are largely employed where, by treatment with sulphuric acid, they have been brought into a quickly active condition. Thus we get dissolved bones or acid superphosphate, the insoluble materials being rendered soluble. It is necessary, however, to discriminate between bone superphosphate and mineral superphosphate, other materials than bone (such as phosphatic rock) being prepared for a similar purpose. Where a crop needs both phosphate of lime, for its phosphoric acid, and nitrogen, dissolved bones may be employed with advantage, unless the soil is of an acid character, or unless nitrogen and phosphoric acid can be purchased in other forms at less cost per lb. Bones, however, are subjected to the process of boiling and steaming for the removal of the gelatine, which is employed for purposes outside

agriculture. By this means the nitrogen is chiefly removed, although the percentage of phosphoric acid is increased.

Basic Slag. This is the ground cinder produced in the process of smelting iron. It contains from 15 to 18 per cent. of phosphoric acid in combination with lime. It is essential in purchasing this fertiliser to compare the prices and percentages of different samples as well as the fineness of the powder, which is all important, inferior samples costing as much for carriage and distribution as the best. The combination of lime with the phosphoric acid renders slag more suitable for soils deficient in lime, and for acid soils, than superphosphates, which are of a highly acid character. Soils which are sour, which are peaty, or which are rich in organic matter of any kind, are benefited by heavy dressings of basic slag, while many of the heavier clays have been so improved by its use that the herbage is not only enriched with clovers and trefoils, but the crops very largely increased in weight.

used, but owing to the higher price of the potash they contain, they usually give way to kainite.

Wood Ashes. Wood ashes, some of which contain as much as 10 per cent. of potash, 3 to 6 per cent. of phosphoric acid, and large quantities of lime, are always valuable as potassic manures, although they are slow acting; but it is a noticeable fact that wherever bushes are burnt, the ashes are wasted.

Seaweed. Seaweed is an organic manure which may be liberally used where the cost of collection is slight. It contains small proportions of nitrogen, phosphoric acid, potash, and lime. Its mechanical value is important on the heavier soils.

Salt (Chloride of Sodium). Salt is employed by many growers of the mangel and of the cabbage with advantage, experimental tests having shown that these crops are frequently larger where it is employed. Salt is believed to exert a mechanical as well as a fertilising action.

This manure is a deposit of sea-birds which feed chiefly upon fish. If of good quality, it is rich in both nitrogen and phosphoric acid. It also contains a small quantity of potash and a liberal percentage of lime. Of late years the quality of guano has diminished, the percentage of nitrogen being reduced. The more recent shipments are chiefly phosphatic in character, the phosphoric acid ranging from 5 to 35 per cent. A fish manure, really produced from fish offal, and described as *Fish Guano*, is found upon the market. This fertiliser is more or less rich in potash as well as nitrogen and phosphoric acid, but is generally inferior to good Peruvian, and before purchase should be compared both as regards price and composition.

Potassic Manures. *Potash* is a fertiliser seldom needed for heavy soils, but frequently employed on peats and lighter soils, especially in the growth of potatoes, clover, and allied plants. The chief supply is found in the mineral deposits near Strassfurt in Germany. The most commonly used of these salts is *kainite*, which contains 13 to 17 per cent. of potash. Muriate of potash and nitrate of potash are occasionally

in lime, and especially where plants like the clovers and the turnip, which need sulphur, are grown. It is quite unnecessary to employ gypsum where bone manures are used.

Gas-lime. This by-product of gasworks is, in its fresh condition, poisonous to plants, owing to the presence of sulphide of lime. Before use, it should be exposed to the air, when, absorbing oxygen, the sulphide is converted into the valuable sulphate. Land needing lime may often be dressed with gas-lime at a lower cost than with fresh or quicklime. It is believed that soil infected by parasitic plants and bacteria dangerous to stock is purified by gas-lime.

Night-soil. Night Soil is a manure of the first rank, containing in its fresh condition larger proportions of nitrogen and phosphoric acid than the manure produced by any class of farm stock. The liquid, however, is not so rich in nitrogen as that of the horse, the cow, or the sheep. Where employed, this fertiliser should be mixed with dry soil, ashes, peat moss, or any absorbent which will assist its conveyance and distribution.

COMPOSITION OF ARTIFICIAL FERTILISERS.—THE FIGURES GIVEN ARE PER CENT.

	Water.	Organic Matter.	Nitrogen.	Phosphoric Acid.	Potash.	Lime.
Nitrate of soda	1·9	—	15·6	—	—	0·2
Sulphate of ammonia	4·0	—	20·0	—	—	0·5
Dried blood	13·4	78·4	11·8	1·2	0·7	0·8
Wool waste	10·0	56·0	5·2	1·3	0·3	1·4
Bone meal	6·0	30·3	3·8	23·2	0·2	31·3
Raw bones	6·2	39·1	3·8	22·3	0·2	29·2
Steamed bones	5·2	17·5	1·6	30·9	0·1	41·8
Dissolved bones	13·0	24·0	2·5	14·7	—	—
Basic slag	—	—	—	17 9	—	58·5
Peruvian guano	16·0	30·0	7·0	9·2	—	—
Fish guano	9·8	56·2	8·5	13·8	0·3	16·0
Kainite	12·8	—	—	—	13·8	1·1
Soot, wood	5·0	71·8	1·3	0·4	0·1	4·0
Soot, coal	6·1	70·4	3·6	—	—	3·9
Rape-cake	9·1	71·1	4·8	2·0	1·3	0·7
Gypsum	20·0	—	—	—	—	31·0
Seaweed	85·0	12·3	0·3	0·2	0·8	0·9
Gas-lime	7·0	1·3	0·4	—	0·2	64·5
Night-soil	77·2	19·8	1·0	1·0	0·25	0·62
Town sewage	99·9	0·006	0·008	0·001	0·001	—

To be continued

Continued from page 375

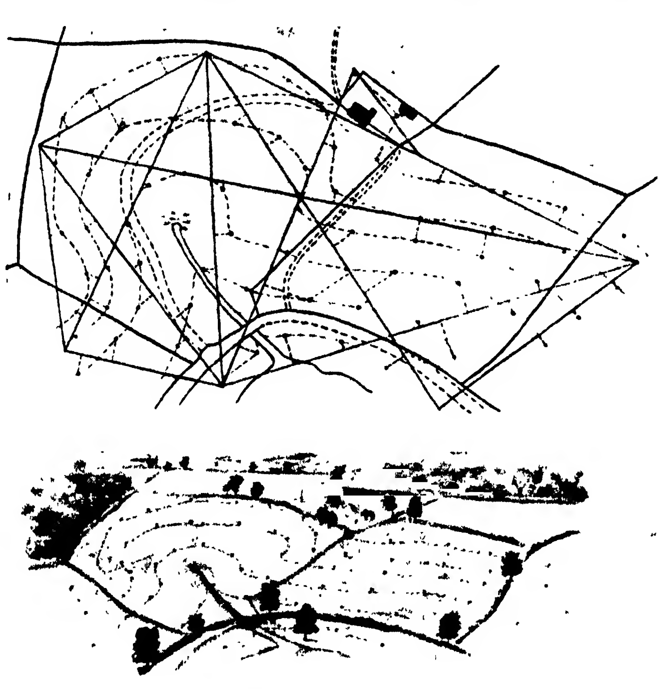
METHODS OF LEVELLING

Contouring. Explanation of the use of the Barometer and Hypsometer. The Aneroid. Triangulation. Measurement of Base Lines

By Professor HENRY ROBINSON

Contouring. Another form of levelling is that known as *Contouring*. A contour survey is one which has for its purpose the establishment of points on the ground of the same level. These points are afterwards picked up by offsets from survey lines, or by lines purposely run for that purpose. A survey of this description is shown in 35.

The method of carrying out a survey of this description is to place pegs, or small flags, in the places which exactly coincide with the required level. The staff is moved about until it reads a figure, which, when reduced, gives the correct level of the ground required. As an example, the value of a bench mark is 104·00, the level is set up and reads on the staff, held on the bench mark, 2·00. This shows the collimation line of the level to be equal to 106·00. If, therefore, it is necessary to obtain the 100·00 contour, the staff would have to be shifted about until it gave readings of 6·00, when those points would be the 100 contour points. Pegs or flags would then be ininserted and numbered, and afterwards picked up by survey lines, as shown in the illustration [35].



35. CONTOURING

Another purpose for which levelling is important is that of setting out gradients, whether for roads, railways, sewers, or other purposes. A gradient is stated in terms of the relation between the vertical fall or rise and the horizontal distance. For instance, when a road is said to have a gradient of 1 in 100 it implies that the vertical rise or fall is 1 unit in 100 units of horizontal measurement.

Degrees of Accuracy. The degree of accuracy that can be attained in levelling depends greatly on the instruments employed, and the care and time which can be devoted to the work. The accuracy which was necessary for the extended Government surveys of Great Britain and India is obviously unnecessary for surveys of comparatively small areas. A good practical standard for ordinary work would be to limit the error to $\frac{1}{10} \times \sqrt{\text{distance in miles}}$; this would give the following permissible errors:

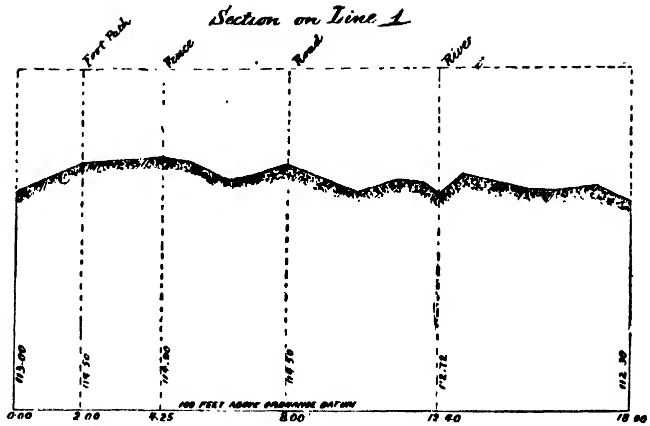
In 1 mile, 0·10 of a foot; 4 miles, 0·20; 9 miles, 0·30; 16 miles, 0·40; 25 miles, 0·50; 36 miles, 0·60; 49 miles, 0·70; 64 miles, 0·80; 81 miles, 0·90; 100 miles, 1·00.

It is necessary for the surveyor to know the value that can be assigned to the tilt of the telescope, corresponding to the displacement of the bubble when not exactly central in its run. With the ordinary levels used in this country $\frac{1}{10}$ inch run of the bubble corresponds to an angle of tilt of the telescope of about five seconds. A good practical rule to remember is that one second of arc is the angle subtended by about $\frac{3}{10}$ inch at a mile, or 0·0156 foot at 10 chains. So that if the bubble be $\frac{1}{10}$ inch out of the centre of its run, there will be an error equal to the above in a 10 chain read.

Plotting Sections. In plotting sections [36] it is usual to employ a scale for the vertical different from that for the horizontal, in order to exaggerate the appearance of the surface of the ground. A horizontal line is first ruled on the paper, and the various distances

at which levels have been taken are marked off on this line. It is generally necessary that this line be assumed to be some fixed number of feet above Ordnance datum, in order that the vertical heights may not be too great.

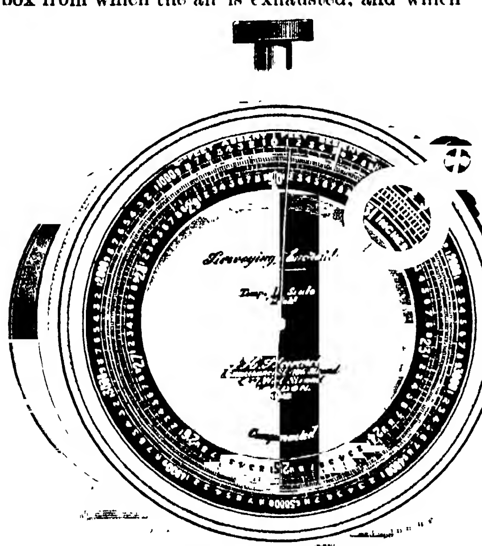
Whatever may be the distance above datum adopted it is written on this line, and must be added to whatever distance is scaled (if the reduced level is not given at the point required). The distances having been plotted, vertical lines are drawn, and the levels of each point scaled up the lines, marked, and the points joined, giving the result of the section taken in the field.



36. LEVEL SECTION

Barometer and Hypsometer. Before leaving the subject of levelling, it is necessary to refer briefly to the Barometer and Hypsometer for ascertaining the altitudes of places. In neither instrument is the accuracy attainable equal to that of staff reading, but both serve for approximate levelling in mountainous districts, and for flying levels in exploring a country. The difference of pressure of the atmosphere at various altitudes affords a direct indication of differences of level. The mercurial barometer (accompanied by a thermometer) is the most reliable instrument for permanent use in meteorological work, but the small range of its fluctuations, and the difficulty of reading the exact level of the mercury, render it less desirable as a levelling instrument than the Aneroid.

The Aneroid. The Aneroid [37] is a *pressure gauge*, consisting of a corrugated metal box from which the air is exhausted, and which is therefore sensitive to external pressure. The expansion of the box actuates suitable levers, springs, and wheel gear, communicating with an indicating pointer which moves round a circle graduated to feet. The scale is also made to correspond to inches of mercury, corresponding to equal arcs on the scale of feet. The instrument is compensated for variations in its own temperature.



37. THE ANEROID

An approximate rule for calculating heights up to several hundred feet is as follows:

Let H = reading in inches on the barometer at lower station.

Let h = reading in inches on the barometer at upper station.

Then $\frac{H - h}{\cdot 0011}$ = height in feet.

A More Accurate Method. For more accurate results the following formula, as given by Professor Rankine, is applicable to the mercurial barometer, with accompanying observations of temperature by two thermometers, one to give the temperature of the air, and the other attached to the barometer to give the temperature of the mercury.

	At Lower Station.	At Higher Station.
Height of mercurial column in the barometer	H	h
Temperature of the mercury in degrees Fahrenheit as shown by the attached thermometer	T	t
Temperature of the air in degrees Fahrenheit as shown by the detached thermometer	T′	t'

Then the height of the higher station in feet above the lower station is:

$$60360\ [\log H - \log h - \cdot 000044\ (T - t)] \times \left(1 + \frac{T' + t' - 64}{986}\right).$$

The last term of the formula is the correction for absolute temperature and becomes unity when T′ and t' are both 32° F.

For rapid calculation without logarithms, the general equation may be written:

Height in feet

$$= 52428 \frac{H - h'}{H + h'}\left(1 + \frac{T' + t' - 64}{986}\right)$$

where h' is the corrected barometric reading at the higher station and equals:

$$h\left(1 + \frac{T - t}{10{,}000}\right)$$

Since the force of gravity varies according to the latitude and altitude, a further correction is needed to represent this.

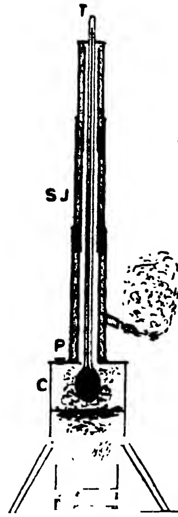
Let a = the mean latitude of the two stations.

Let h_m = their mean height above the sea.

The difference of level given by the previous formulæ must be multiplied by:

$$1 + {\cdot}00284 \cos 2a + \frac{h_m}{10{,}450{,}000}$$

In taking observations with the barometer it is well to have one instrument at the starting station, and observations taken with it at stated intervals all day, for comparison with the instrument used for taking the altitudes.



38. HYPSOMETER
T. Thermometer
SJ. Steam Jacket
P. Water Supply Plug
C. Copper Boiler

The Hypsometer. [38] The relation between the "Boiling Point of Water" and the pressure on its free surface affords a means of calculating elevations. The boiling point of water at sea-level when the barometer stands at 29·922 inches is 212° Fahrenheit. As the altitude increases the boiling point is lowered. A special instrument is made for the purpose of noting the boiling point with great accuracy.

The Hypsometer consists of a bulbed thermometer with a long stem, and graduated scale, reading only within the limited range of 180° to 214° Fahrenheit, so as to enable the scale to be read to tenths of a degree. The bulb is enclosed in a small boiler, and the stem is surrounded by two cases through which the steam circulates.

The following formula gives a close approximation for the heights of stations as found with the Hypsometer:

$$H = 519\,(212 - T) + (212 - T)^2$$

Where

H = height in feet of any station (A) above another where the boiling point of water is 212° F.

T = boiling point of water at the station (A) in degrees Fahrenheit.

Example. Let A and B be two stations whose difference of level is to be determined.

At A the boiling point is observed as		201° F.
,, B ,, ,, ,, ,,	,,	210° F.
,, A ,, air temperature ,,	,,	65° F.
,, B ,, ,, ,, ,,	,,	59° F.

Height of A above 212° boiling point station by formula .. .. = 5830 feet

Height of B above 212° boiling point station by formula .. .. = 1042 feet

Difference = 4788 ,,

This difference must be multiplied by

$$\left(1 + \frac{T' + t' - 64}{986}\right)$$

to find the correction for the actual temperatures, and also by the formula given previously for altitude.

Triangulation. Having explained the various methods that are employed in surveying where the lines are measured, it is now necessary to deal with the subject from the point in which direct measurement is done away with, except for the purpose of getting accurately a base line from which to begin operations. This is known as *triangulation*.

Triangulation is the surveying of a tract of land by dividing it up into a system of triangles, built up from a measured base, the triangles forming in themselves a series of polygons. It is known from mathematics that:

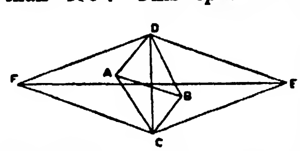
1. The three angles of any triangle are equal to 180°.
2. The sum of the central angles of a polygon are equal to 360°.
3. The sum of the internal angles in any polygon, plus four right angles, equals twice as many right angles as the figure has sides.

In this course, as before mentioned, the spherical shape of the earth is neglected, except for the purpose of reducing the measured base to mean sea-level. It is not intended to describe the methods of triangulation which were adopted for the great trigonometrical surveys of England or India, as for that purpose a considerable knowledge of mathematics and astronomy was necessary, and as it would carry this course beyond the limits prescribed for it.

It is necessary, however, for every civil engineer and surveyor to have some knowledge of triangulation, and the purposes for which it is employed. The triangulation of this country was divided into three systems:

1. The primary, or great instrumental work
2. The secondary triangulation.
3. The minor, or parish work.

Spherical Excess. In the primary triangulation of any country where the lengths of the sides are considerable, the spheroidal shape of the earth's surface will affect them. The angles read between the lines will be spherical angles, and their sum in any triangle is greater than 180°. This *spherical excess* has to be corrected in order to reduce the spherical angles to plane angles and to solve the triangles as plane triangles. For the purposes of this

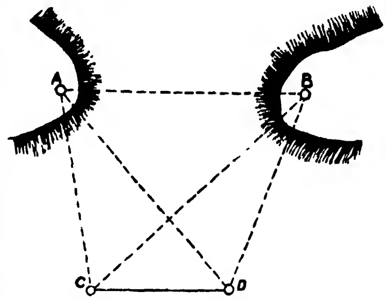


39. BASE LINE BY CALCULATION

course (other than the brief note above), the earth's surface will be assumed to be flat, and this will not lead to any appreciable errors in ordinary triangulation work.

As before stated, the survey is built on a base line measured with the greatest accuracy, as the whole of the after-work depends on it.

The Heliostat. When the stations are very far apart, use is sometimes made of the sun by an instrument called the *Heliostat*. This is simply a mounted mirror, with a small part of the silvered backing scraped away, making a blind spot. The rays of the sun are reflected to the required station, and readings taken to the blind spot in the centre of the mirror, by which means the position of the station where the Heliostat is mounted can be fixed,



40. SIMPLE TRIANGULATION

Steel tapes are often used for this purpose, but the method must depend on the accuracy that is required. The bases of the Indian triangulation were measured with Colonel Colby's compensating bar of 10 ft. in length, from which it will be seen that the process is a tedious one. The selection of the position for this base line requires care, and must be on fairly flat ground. At the same time, it should be in such a position that the surrounding points to form the survey are easily obtainable. It is much better to choose a shorter base, and have it accurately measured, than a longer line where the same accuracy is not attainable. In the event of the impossibility of obtaining a measured base of sufficient length a longer one must be obtained by calculation.

In the illustration [**39**], A B is the measured base. From the points A and B angles are taken to C and D. After C and D are fixed, angles are taken from them to E and F, and by this means a base line, EF, is obtained, which can be considerably longer than AB.

It is a good practice to lay down a skeleton plan of the various points that are selected for stations in order that the best arrangement of triangles may be decided on. The equilateral triangle is the best, and the aim of the surveyor should be to arrange his triangulation so as to obtain no "ill-conditioned" triangles.

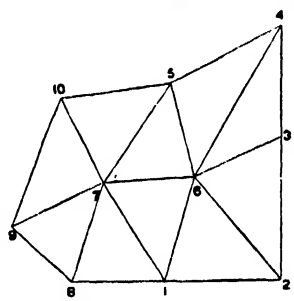
If a rapid preliminary survey be first made with a compass, sextant, or plane table, a preliminary arrangement of lines may be laid down, and plotted approximately, by which an idea can be formed as to the best arrangement of lines.

Trigonometrical Formula. The calculation of the lines is based on the well-known trigonometrical formula

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

where a, b and c are the lengths of the sides, and A, B and C their respective angles. Having, therefore, the length of any one side, and the angles being observed, the lengths of the other sides may be calculated by the formula.

One of the simplest cases is that shown in **40**. The base line CD is chained, preferably an even number of chains. The theodolite is set up at C and D, and the angles ACB, BCD, ADC, and ADB are taken, and the lengths of the sides AC, BC, AD and BD calculated by the formula. The angles at A and B are then observed, and the distance AB calculated; the points A and B can then be used for further triangulation. A general example of a preliminary survey is shown by **41**.

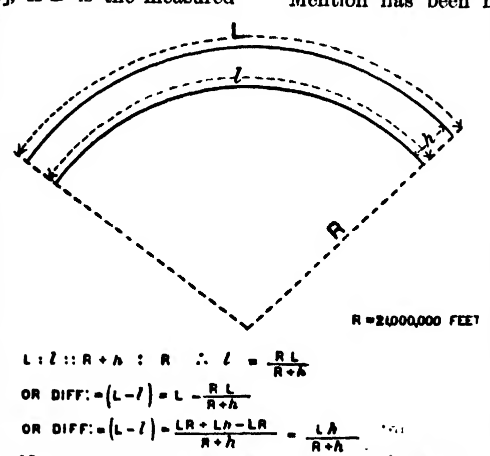


41. PRELIMINARY SURVEY

One of the lines is measured (as, for instance, 1—8), and upon it the triangulation is built. The angles at 1 and 8 are observed, and 7 is fixed. This point is the centre of a polygon 8, 9, 10, 5, 6, 1, 8, and, as explained before, the angles taken at 7 must equal 360°.

Mention has been made of the necessity of reducing the base line to mean sea-level. The illustration [**42**] gives the calculations necessary for this, assuming the earth's mean radius to be 21,000,000 ft., which is a close approximation.

In the formula, L equals the length of the base as measured at an altitude h, and l equals the length of the base reduced to mean sea-level. It is necessary to be able to fix the position of the true north in order to correct for the variation of the needle.



42. REDUCTION OF BASE TO MEAN SEA-LEVEL

To be continued

Group 2
ART
3
Continued

LINEAR & AERIAL PERSPECTIVE

The Vanishing Point. Mathematical Devices. The Centrolinead. Shading. Aerial Perspective

By P. G. KONODY and HALDANE MACFALL

Perspective. The student should keep a rough rule of thumb over his perspective. The full laws of perspective are elaborate, but are fortunately not required for an artist's every day use; but the main laws he must use constantly, for his point of sight determines the place of things in his picture. As he draws an object, the point opposite his eye is very valuable, for from it radiates the height and breadth of all his forms. All his drawing will depend for its accuracy of position in the picture on its relation to the horizontal line drawn through this point.

The student must acquire a sound knowledge of elementary geometry [see MATHEMATICS and DRAWING] before proceeding. Take a diamond fixed at the end of a metal stick and stand with your head within arm's reach of a window. Close one eye and mark on the glass pane in outline what the other eye sees through the window, and you have an absolutely correct perspective of what is outside scratched on the flat glass.

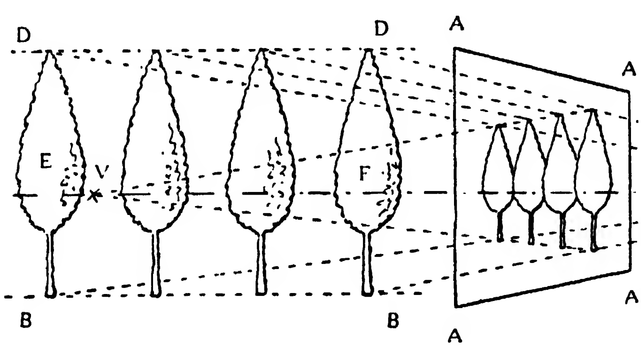
Figure 1 shows a row of trees so treated, except that the relative sizes of the features are altered for the purpose of clearer demonstration. Let $AAAA$ stand for the glass pane. It will be noticed that the ground line of the trees BB (which in reality is horizontal or level) shows on the glass a line going upwards; and, on the contrary, the top line of the trees, DD, which is equally level, shows on the glass a line going downwards. These two lines, when continued, meet always at some point, V, on a line level with the eye which has drawn the picture, and in consequence a row of trees or other similar equal-sized objects along a straight surface always look smaller as they go backward in a picture until, if continued far enough, they appear to vanish into nothing.

The optical reason for this is self-evident when we reflect that all things we see have to come into one point at the back of the eye; consequently all things above the level line HH are seen more from *beneath* them, as they advance towards the eye, and all things below the line HH more *above* as they advance towards the eye. Hence the tree at F becomes drawn on the glass pane much taller than the equal-sized tree further back at E.

This comprises the entire principle involved in perspective drawing. Once this is grasped, the rest becomes a matter of practice in drawing from visible objects; but when the object has to be designed or evolved direct from the brain, such as in architecture, the following mathematical method is pursued to get at the same result.

Mathematical Devices. First, plans and elevations are drawn isometrically to a given scale, such as one-eighth of an inch for every foot, or larger according to the amount of detail the subject contains. Figures 2 and 3 show a primitive tower so treated. Choose on the plan the spectator point S, corresponding to the position of the eye in Fig. 1. Draw from S lines SA and SB to the extreme points on each side of the object to be represented in perspective. This is called the visual angle or range of view. Bisect it—SF. Then any line perpendicular to SF, such as PP, stands for the pane of glass in the window and is called the picture plane. The nearer you make the line to S, the smaller will be the size of the ultimate picture.

From S draw SV^1 and SV^2 parallel to AG and BG respectively. These, at their intersection with the picture plane PP, give vanishing points corresponding with the point V in Fig. 1. Each vanishing point is usable in perspective for the surface or plane from which it has been thus derived, or any surface parallel to that surface.

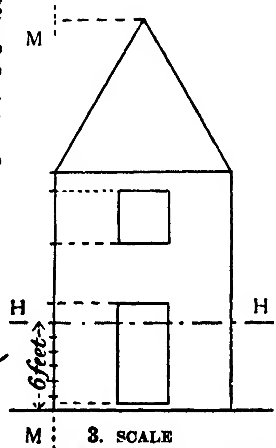


1. A PERSPECTIVE OF A ROW OF TREES SEEN AND DRAWN ON A GLASS PANE

Thus the pavement kerb in front of AG will vanish to the same point as AG.

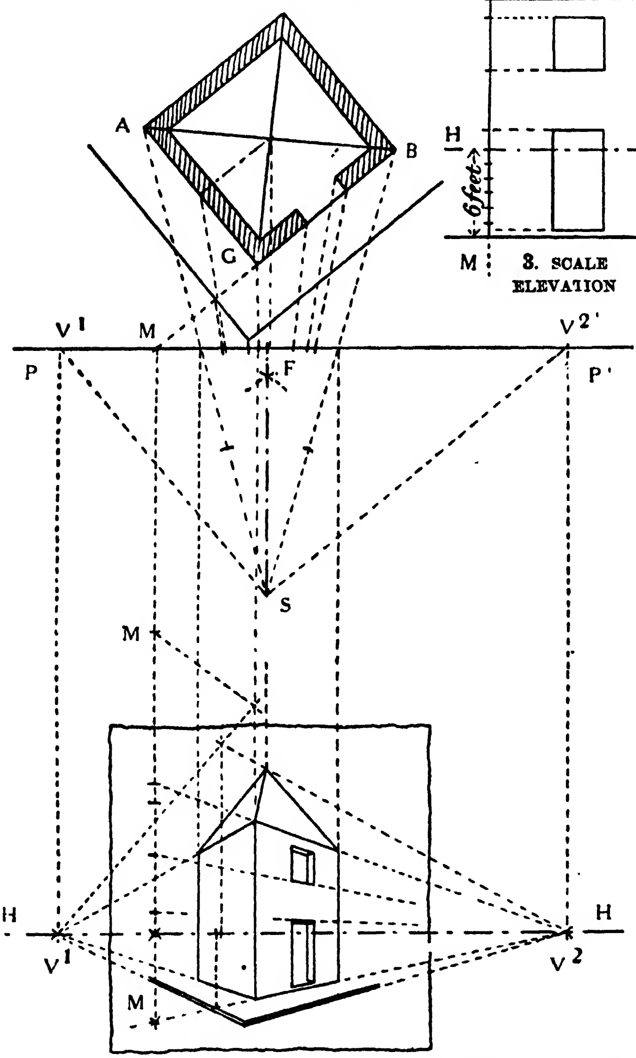
Then project BG, on plan, to M, which gives the point at which to erect the vertical " measuring line " for all heights on the scale elevation of BG shown in 3. Then draw on the perspective sheet HH, called the horizon line and corresponding with HH in 1 and 3. Tick off on it all the intersection points seen along PP on plan. Then decide how high the spectator's eye shall be when drawing the picture, say, six feet from the ground. Scale six feet on measuring line MM, from level of horizon line HH downwards, and this gives the ground line of tower. Then tick off along MM the scale heights of features on tower, got from 3. The rest of the processes becomes self-evident.

It will be noted that the nearer the spectator point S is to the plan of the building or object, the larger becomes the visual angle ASB, and the more acute is the resultant perspective. Consequently there is a limit to the size of this angle. The general rule is to keep it more or less between 30 and 45 degrees, according to the effect sought for, unless under exceptional circumstances, it being found that sometimes presentments which are too stilted to be in reality practically visible to any eye, may occasionally be required on a drawing.



3. SCALE ELEVATION

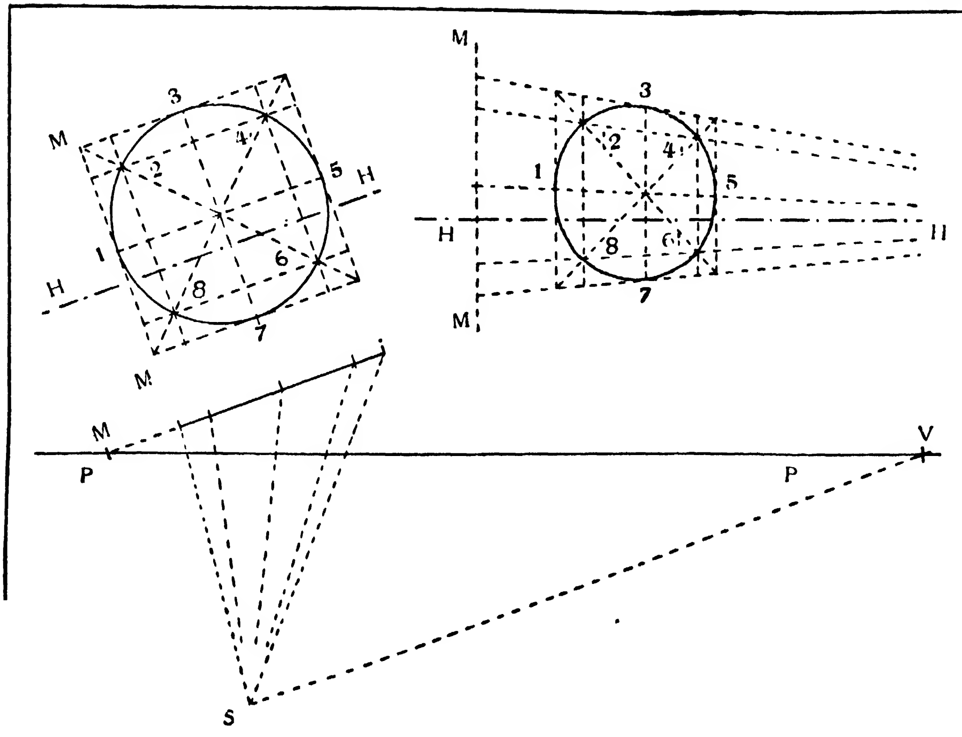
The same applies to the rule of making the picture plane PP perpendicular to the bisector [SF] of the visual angle. It is sometimes stilted as in 6. The question whether such abnormal devices are permissible must be left to trained judgment, having regard to the ultimate effect sought for in each picture.



HOW A PERSPECTIVE IS OBTAINED BY MATHEMATICAL DEVICES FROM PLAN AND ELEVATION

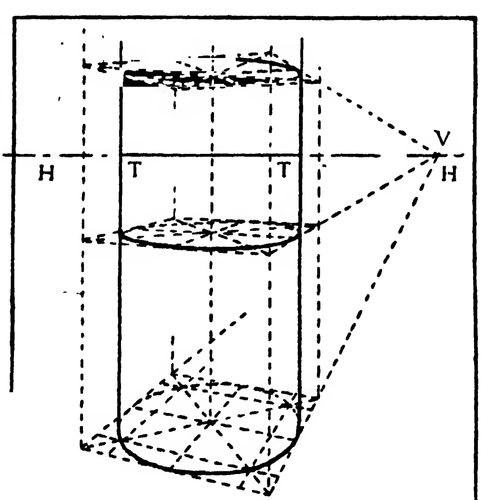
Circles and Other Curves. Up to now we have had to deal with straight lines. Circles and other curves are treated by selecting a number of points upon them and then putting these points into perspective by the same process as before; after which a line is drawn bent to pass through those points. Figure 4 shows a circle so treated, the numbers 1 to 8 being the points referred to. This is a vertical or upright circle. A horizontal or plan circle [5] is obtained in a similar way. In 5 is also shown the same circle as seen when it is placed higher up towards the eye level, or line of horizon, HH. It will be noted that the resultant oval has the same width as the lower one, but is not so deep; and this depth grows more and more narrow till, when the circle is on the actual level of the eye, TT, *it is seen as a straight line only*. The same phenomenon occurs *inversed* when this same circle is seen at any height *above* the eye or line of horizon.

When the drawings are large, one or more vanishing points are sometimes too far away to be accessible on the draughtsman's table on either side of him. In that event several methods have been devised for overcoming the difficulty. The two following are the most



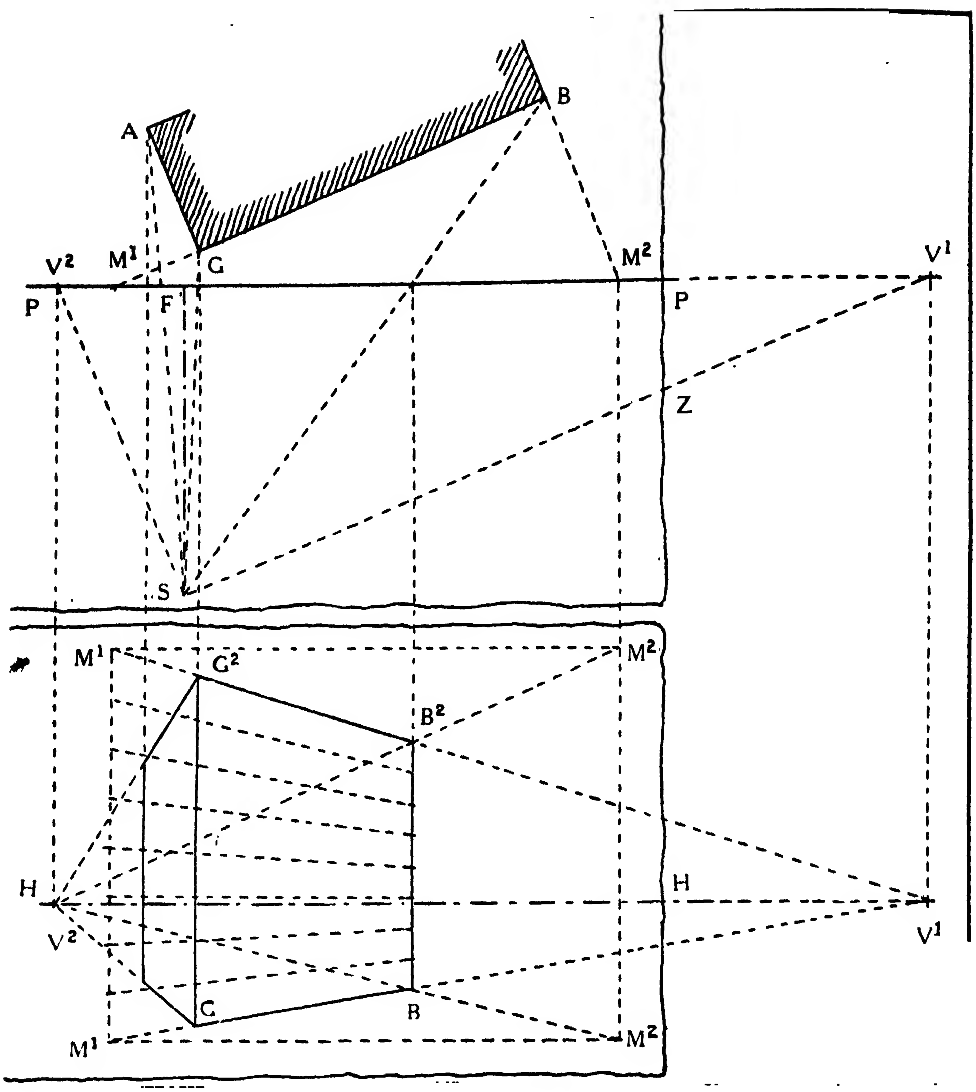
4. A CIRCLE DRAWN IN PERSPECTIVE

serviceable: Figure 6 serves when a surface, GB on plan (and all surfaces parallel to it), has an inaccessible vanishing point, V^1, but when the vanishing point of its corresponding right angle on plan, GA, is accessible V^2. As the lettering to the lines and points in 6 corresponds with those in 2, the reader will be familiar with their working till the line SV^1 is stopped short at Z by want of room to continue it. Instead of drawing SV^1 draw BM^2, which is parallel to AG, and gives a second measuring line M^2M^2. Tick off the work on the perspective sheet and draw ground line M^1M^2 and mark a convenient equal distance M^1M^1 and M^2M^2. Then draw V^2BM^2 and $V^2B^2M^2$, thus obtaining the lines M^1B and M^1B^2, which, if continued, would meet at the inaccessible vanishing point V^1. Then divide M^1M^1 and BB^2 into a convenient number of equal parts; unite them respectively, and you have a scale of vanishing lines, any intermedial lines you may require being put in by eye. At first you may require a very close vanishing scale by making the equal divisions very small, but, with training, your eye will find itself able to manage with much wider spacing.



5. A HORIZONTAL CIRCLE DRAWN IN PERSPECTIVE BELOW AND ABOVE THE LINE OF HORIZON

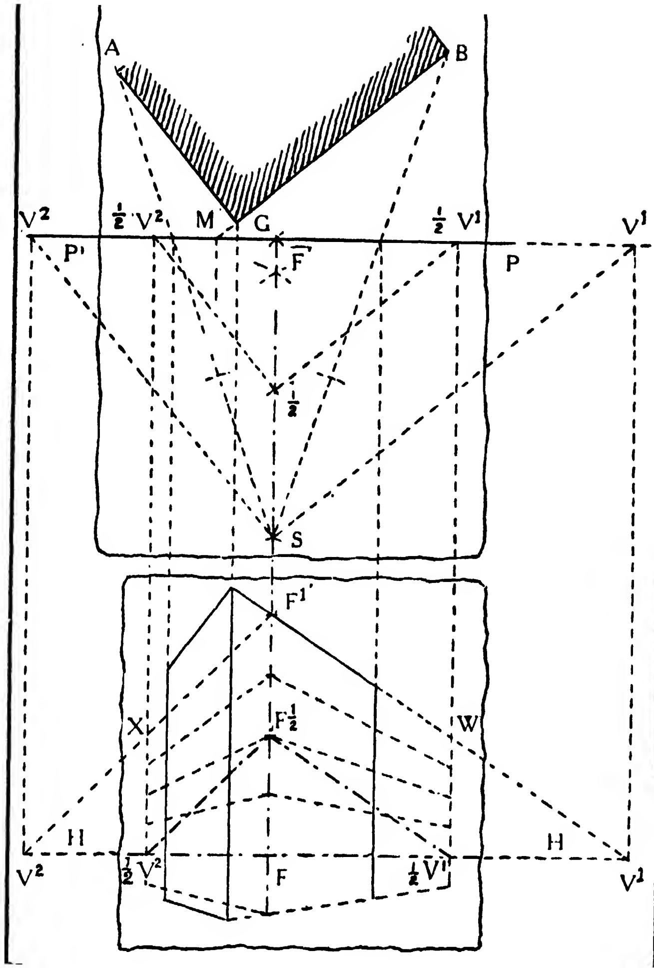
Figure 7 serves when you are hampered for room on both sides. In that event you divide SF (the perpendicular line from S to the picture plane PP) into an equal number of parts according to the room at sides you have at your disposal—say, into halves. Then connect ½ with ½ V^1 and ½ V^2 respectively parallel to GB and GA, the surfaces whose inaccessible vanishing points you are dealing with. Then it is obvious that the



6. HOW TO FIND AN INACCESSIBLE VANISHING POINT

points $\frac{1}{2} V^1$ and $\frac{1}{2} V^2$ will be respectively half way to the inaccessible points in question. Mark on the perspective sheet, along line FF^1, a convenient distance FF^1; halve it and draw $F \frac{1}{2} \frac{1}{2} V^1$ and $F \frac{1}{2} \frac{1}{2} V^2$; then from F^1 draw lines parallel to them, F^1W and F^1X; and it is obvious that these lines, if prolonged, would respectively pass through the inaccessible vanishing points V^1 and V^2. From that proceed to draw vanishing scales in the same way as the scale in 6.

The Centrolinead. There is an instrument called a Centrolinead [8] much used for drawing lines to inaccessible vanishing points after the two first lines to any inaccessible point have been obtained by the methods described. It consists of three straight edges hinged at A and fitted with screw stops whereby the three arms can be fixed at any angle to each other. Three lines so determined have a property in geometry, that when two of them (AC and AD) are placed against any two fixed points or pins (EF) and made to slide up or down against them, the third line (AB), at any place on its radial journey, will take a direction which, if continued, would meet at one centre V. The instrument is adjusted on the perspective sheet (between any two vanishing lines obtained as described in 6 and 7) by observing that the further point V is away, the larger should angle CAD be made, and the wider the pins EF be fixed. Also note that the angles CAB and DAB need not be equal. Many beginners lose patience with the centrolinead because of the time its adjustment entails,



7. HOW TO FIND TWO INACCESSIBLE VANISHING POINTS

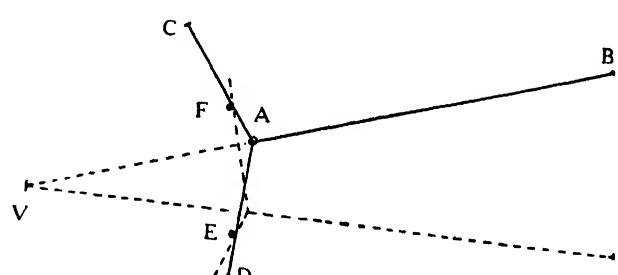
but this disappears directly a little practice has enabled the student to grasp the geometrical principle involved.

Having mastered the rudiments of perspective as applied to simple buildings or objects, the student will find, on proceeding to more complex structures, that to draw in every detail by the same mathematical process becomes complicated, and the many operations first required involve him more and more into a fog of tantalising lines in all directions. To minimise these he makes for means which do not require so much preliminary reference to the isometrical plan and elevations.

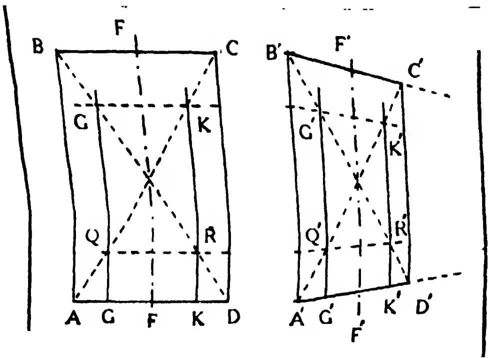
One of the main principles from which these shorter methods are evolved is the root property of a diagonal line. In **9**, $ABCD$ is the isometrical or flat elevation of a rectangular surface, and $A^1B^1C^1D^1$ is that surface put into perspective. By drawing diagonal lines the centre line FF is obtained, and the centre line F^1F^1 can be got direct by the same principle. Also, in the case of any line, such as $G\,G$, on one side of the centre, you can draw a corresponding line, KK, on the other side of the centre at equal distance from it by drawing G^1K^1 or Q^1R^1 direct on the perspective.

This principle, carried further, enables you to divide, direct in perspective, a surface into any number of equal parts. Suppose you have to draw a row of any objects such as men or trees standing equi-spaced along a straight line, say a row of 6 columns [**10**]. First get, by the plan, the centre line of the column at each end of the row, AB and CD. Divide AB into five equal parts, draw vanishing lines through each of these divisions, and draw the diagonal line AD intersecting the vanishing lines. Then mark the points where division lines give respectively the centre lines of the intermediary columns in perspective.

To find the width of the columns, note the ratio, or how many times the width of one column goes into its height. Say it is eight times. Tick off one-eighth space at EF and the same vertically at E^1F^1, draw vanishing lines through E^1 and F^1, and you get the diminishing widths of the remaining columns.



8. CENTROLINEAD



9. THE USE OF DIAGONALS

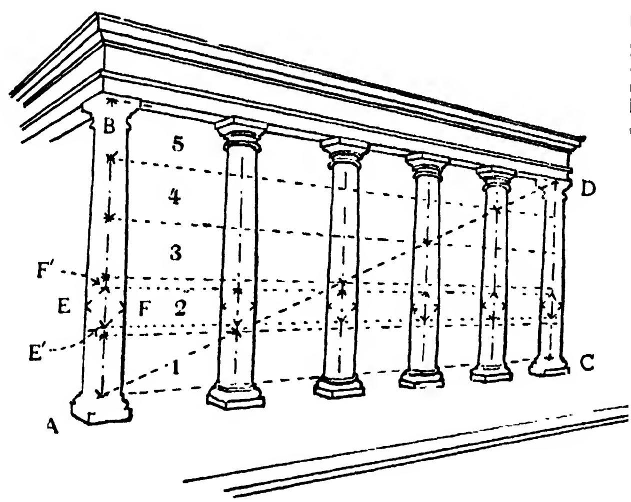
Further labour-saving processes such as these the draughtsman soon finds himself discovering, and, assisted by an ever increasing accuracy of eye, he is enabled eventually to "think in perspective." Then it is surprising how very few plan-derived lines he requires for an efficient perspective representation even of very elaborate, difficult themes, such as an ornate palace or the interior of a theatre.

Shading. After a picture has been outlined in linear perspective, its shading has to be considered. When an object stands in the way of sun-rays, any of its sides which are more or less to the back of the sun, are said to be in shade, and the intercepted rays cause a shape (derived from the outer boundary of the object) to be cast, as a silhouette of that object, on to the ground or other surfaces which may be within the field of operation. This is called the shadow. To draw in perspective the outlines of shadows, note that sun-rays are all taken as parallel lines. Therefore treat the projected shadow of any object as an isometrical projection of that object from one plane to another (see article on GEOMETRY). After this put into perspective the outlined *plan* of the shadow thus obtained—an operation done by the same perspective rules as those already explained.

Then comes the question of tones for shades, shadows, and local colours. A surface in shade has a lighter tone than the shadow it casts. The brighter the light the darker the shadow, and the more marked the difference in depth of tone between shade and shadow. Tones other than those showing shades and shadows stand for the local colours of the objects seen, and vary in depth accordingly.

Aerial Perspective. Finally, the whole of the tones are affected by what is called aerial perspective. Here the principle involved has to do with the relative density of the atmosphere through which objects are seen, by reason of that density affecting the vision through which it may be said to have to pierce. Hence, for instance, distant mountains appear misty grey or blue, though their actual colour, when seen near, may be otherwise, such as bright or dark green. Observation and practice alone can efficiently reveal the facts of aerial perspective, after the mind has been warned to look out for them.

Thus perspective and the proportions of the human figure should be mastered from the very outset. There is no better teacher of drawing than the human figure. All the time that the student is mastering the human form and drawing its anatomy stripped of the beautifying skin (not learning it by rote, like words, be it remembered), he is increasing his powers with the pencil. And in just the same way it is well to practise circular flat forms, cones, squares, and so on, above and below the eye, to get the perspective effects correctly.



10. A SHORT METHOD OF DRAWING A ROW OF COLUMNS IN PERSPECTIVE

To be continued

LATIN AND ENGLISH

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LATIN

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Section I. GRAMMAR.

Pronouns and Adjectives: Peculiar Declensions. Some numeral adjectives, and all the pronoun-adjectives except *meus, tuus, suus, noster*, and *vester*, have the ending *-ius* for all genders of the genitive singular, and *-i* for all genders of the dative singular. The words belonging to this class are *unus* (one), *ullus* (any at all), *nullus* (none), *solus* (alone), *totus* (whole), *alter* (the other), *uter* (which of two), and its compounds *uterque*, etc., *neuter* (neither), *alius* (other, another), *ille, iste, ipse, hic, is, idem, qui*, and all its compounds. The last seven have already been declined. The first five are declined like *bonus* (except, of course, genitive and dative singular), *alter*, like *tener*, and *uter* and *neuter*, like *niger* (except genitive and dative singular). *Alius* has its neuter, nominative and accusative singular ending in *-d*.

The following rhyme may be helpful:

"Unus, solus, totus, ullus,
Uter, alter, neuter, nullus."

Examples:

Singular.

	Masc.	*Fem.*	*Neut.*
N.	alĭus	alĭa	alĭud
Acc.	alium	aliam	aliud
Gen.		alĭus	
Dat.		alii	
Abl.	alio	alia	alio

Plural.

	Masc.	*Fem.*	*Neut.*
Nom.	alii	aliæ	alia
Acc.	alios	alias	alia
Gen.	aliorum	aliarum	aliorum
D. & Abl.		aliis	

Singular.

	Masc.	*Fem.*	*Neut.*
Nom.	unus	una	unum
Acc.	unum	unam	unum
Gen.		unius	
Dat.		uni	
Abl.	uno	una	uno

Plural.

	Masc.	*Fem.*	*Neut.*
Nom.	uni	unæ	una
Acc.	unos	unas	una
Gen.	unorum	unarum	unorum
D. & Abl.		unis	

Note. *Unus* in the plural is used only with nouns whose plural denotes a singular, as *una castra* = one camp (*castrum* = a *fort*; *castra*, plural = a camp).

Before leaving the pronoun-adjectives, the following correlatives may be noticed:

Interrogative. Qualis (of what kind); quantus (how great); quot (how many).

Demonstrative. Talis (such); tantus (so great); tot (so many).

Relative. Qualis (as); quantus (as); quot (as).

Indefinite. Aliquantus (of some size); aliquot (some few).

Universal. Qualiscumque (of what kind soever); quantuscumque (how great soever); quotcumque (how many soever).

The Numerals. There are four main kinds:

1. Cardinal (one, two, three), answering the question *quot* = how many (adjectives).
2. Ordinal (first, second, third), answering the question *quotus* = which, in numerical order (all declinable adjectives).
3. Distributive (one each, two each), answering the question *quoteni* = how many each (all declinable plural adjectives).
4. Adverbial (once, twice), answering the question *quotiens* = how many times (adverbs, and therefore indeclinable).

	Cardinal.	*Ordinal.*	*Distributive.*	*Adverbial.*
1.	unus, a, um	primus, a, um prior, first of two	singuli, æ, a	semel
2.	duo, æ, o	secundus alter	bini	bis
3.	tres, tres, tria	tertius	terni *or* trini	ter
4.	quattuor	quartus	quaterni	quater
5.	quinque	quintus	quini	quinquiens
6.	sex	sextus	seni	sexiens
7.	septem	septimus	septeni	septiens
8.	octo	octavus	octoni	octiens
9.	novem	nonus	noveni	noviens
10.	decem	decimus	deni	deciens

	Cardinal.	*Ordinal.*	*Distributive.*	*Adverbial.*
11.	undecim	undecimus	undeni	undeciens
12.	duodecim	duodecimus	duodeni	duodeciens
13.	tredecim	tertius decimus	terni deni	terdeciens
14.	quattuordecim	quartus decimus	quaterni deni	quater deciens
15.	quindecim	quintus decimus	quini deni	quindeciens
16.	sedecim	sextus decimus	seni deni	sedeciens
17.	septendecim	septimus decimus	septeni deni	septiens deciens
18.	duodeviginti (two from 20)	duodevicesimus	duodeviceni	duodeviciens
19.	undeviginti	undevicesimus	undeviceni	undeviciens
20.	viginti	vicesimus	viceni	viciens
21.	unus et viginti *or* viginti unus	unus et vicesimus (*rarely* primus)	viceni singuli	semel et viciens
22.	duo et viginti *or* viginti duo	alter et vicesimus	viceni bini	bis et viciens
30.	triginta	tricesimus	triceni	triciens
40.	quadraginta	quadragesimus	quadrageni	quadragiens
50.	quinquaginta	quinquagesimus	quinquageni	quinquagiens
60.	sexaginta	sexagesimus	sexageni	sexagiens
70.	septuaginta	septuagesimus	septuageni	septuagiens
80.	octoginta	octogesimus	octogeni	octogiens
90.	nonaginta	nonagesimus	nonageni	nonagiens
100.	centum	centesimus	centeni	centiens
200.	ducenti, æ, a	ducentesimus	duceni	ducentiens
300.	trecenti	trecentesimus	treceni	trecentiens
400.	quadringenti	quadringentesimus	quadringeni	quadringentiens
500.	quingenti	quingentesimus	quingeni	quingentiens
600.	sescenti	sescentesimus	sesceni	sescentiens
700.	septingenti	septingentesimus	septingeni	septingentiens
800.	octingenti	octingentesimus	octingeni	octingentiens
900.	nongenti	nongentesimus	nongeni	nongentiens
934.	nongenti triginta quattuor			
1,000.	mille	millesimus	singula millia	milliens
2,000.	duo millia	bis millesimus	bina millia	bis milliens
500,000.	quingenta millia	quingentiens millesimus	quingena millia	quingentiens milliens
1,000,000.	deciens centum millia	deciens centiens millesimus	deciens centena millia	deciens centiens milliens

NOTE. The cardinal numbers from *quattuor* to *centum*, inclusive, are indeclinable; *unus* has been declined above; *duo* and *tres* are declined thus:

	Masc.	*Fem.*	*Neut.*
N	duo	duæ	duo
Acc.	duos (*or* duo)	duas	duo
Gen.	duorum	duarum	duorum
D. & Abl.	duobus	duabus	duobus

N.	tres		tria
Acc.	tres		tria
Gen.		trium	
D. & Abl.		tribus	

Ambo (both) is declined like *duo.*

Mille, used as an adjective, is indeclinable: but when used as a noun, it has a declinable plural *millia, millium, millibus* — *e.g., mille milites* = 1,000 soldiers; *tria millia militum* = 3,000 soldiers (literally, three thousands of soldiers).

Duo- and *un-* in composition (as in duodecentum = 98) do not change, whatever be the case or gender.

The Distributives are used:

1. To denote that the number belongs to each of several persons or things—*e.g., quinos comites adduximus* = we brought five companions each.

2. In expressions of multiplication—*e.g., bis bina* = twice two; *deciens centena millia* = a million (100,000 taken each of ten times).

3. With nouns which have no singular, or differ in meaning in singular and plural—*e.g., bina castra* = two camps. In this sense, *uni,* not *singuli,* is used (see above, *una castra*); also *trini,* not *terni*—*e.g., trinæ aedes* = three houses (*aedes* in singular = room or temple; in plural, = a set of rooms—*i.e.,* a house).

The ordinals, not the cardinals, are used in giving the date—*e.g.,* in the year 1905 = *anno millesimo nongentesimo quinto.*

Multiplicative adjectives are formed with the suffix *plex* = fold—*e.g., simplex, duplex, triplex, decemplex, centuplex.*

Every other is expressed by *alterni*—*e.g., alternis diebus* = every other day (ablative of time at which: literally, on every second day).

SCHEME OF THE FOUR CONJUGATIONS—PASSIVE VOICE

Indicative Mood.

		Singular. 1.	2.	3.	*Plural.* 1.	2.	3.
Present.							
Am-	or (I am loved)		aris	atur	amur	amini	antur
Mon-	eor (I am warned)		ēris	ētur	ēmur	ēmini	entur
Reg-	or (I am ruled)		ĕris	ĭtur	ĭmur	ĭmini	untur
Aud-	ior (I am heard)		īris	ītur	īmur	īmin	iuntur
Future Simple.							
Ama-, Mone-	bor		beris (*or* bere)	bitur	bimur	bimini	buntur
Reg-, Audi-	ar		ēris (*or* ēre)	ētur	emur	emini	entur
Imperfect.							
Ama-, Mone-, Rege-, Audie-	bar		baris (*or* bare)	batur	bamur	bamini	bantur

Perfect.

Amatus sum, amatus es, amatus est — Amati sumus, estis, sunt
Monitus sum, monitus es, monitus est — Moniti sumus, estis, sunt
Rectus sum, rectus es, rectus est — Recti sumus, estis, sunt
Auditus sum, auditus es, auditus est — Auditi sumus, estis, sunt

	1.	2.	3.	1.	2.	3.
Future Perfect.						
Amat-, Monit-, Rect-, Audit-	us ero	us eris	us erit	i erimus	i eritis	i erunt
Pluperfect						
Amat-, Monit-, Rect-, Audit-	us eram	us eras	us erat	i eramus	i eratis	i erant

Subjunctive Mood.

		Singular.			*Plural.*	
Present.						
Am-	er	eris (*or* ēre)	etur	emur	emini	entur
Mone, Reg-, Audi-	ar	aris (*or* āre)	atur	amur	amini	antur
Imperfect.						
Ama-, Monē-, Regĕ-, Audi-	rer	reris (*or* rere)	retur	remur	remini	rentur
Perfect.						
Amat-, Monit-, Rect-, Audit-	us sim	us sis	us sit	i simus	i sitis	i sint
Pluperfect.						
Amat-, Monit-, Rect-, Audit-	us essem	us esses	us esset	i essemus	i essetis	i essent

Imperative Mood.

Present Tense. 2nd Sing.	2nd Pl.	*Future Tense.* 2nd Sing.	3rd Sing.	3rd Pl.
amare (be thou loved)	amamini (be ye loved)	amator (thou must be loved)	amator	amantor
monēre	monemini	monētor	monētor	monentor
regĕre	regĭmini	regĭtor	regĭtor	reguntor
audire	audīmini	audītor	audītor	audiuntor

Infinitive Mood.

Pres. and Imperfect.		*Perf. and Pluperfect.*	
ama-	ri	amat-	us esse
mone-	ri	monit-	us esse
reg-	i	rect-	us esse
audi-	ri	audit-	us esse

Future Infin.		*Perfect Participle.*	
amat-	um iri	amat-	us, a, um
monit-	um iri	monit-	us, a, um
rect-	um iri	rect-	us, a, um
audit-	um iri	audit-	us, a, um

Gerundive.

amand-	us, a, um
monend-	us, a, um
regend-	us, a, um
audiend-	us, a, um

[Refer back to Table giving derivation of the verb forms, on page 244, and trace out all the passive forms.]

NOTES. 1. There is an alternative form in 2nd singular, present, indicative, passive (*ris* or *re*)—*e.g.*, *amaris* or *amare*. But the latter is seldom used, on account of the confusion with infinitive active and imperative passive (both *amare*).

2. Note how much the perfect participle passive is used. It forms all the perfect tenses, indicative and subjunctive, with parts of *sum*. It is declined like *bonus*—*e.g.*, *puellæ amatæ sunt* = the girls have been loved.

3. The gerundive is a verbal adjective; its use will be explained later.

4. There are three participles wanting in Latin:

(*a*) Act. Perf. Ptc., "having loved." We must use *quum amavisset* = when he had loved, or some similar construction.

(*b*) Pass. Pres. Ptc., "being loved." Say *qui amatur* or *dum* (while) *amatur*.

(*c*) Pass. Fut. Ptc., "about to be loved." Say *qui amabitur* or something similar.

But note carefully that *amatus* does *not* mean "having loved." It means "having been loved." The importance of this will appear later.

SECTION II. SYNTAX.

The Ablative Absolute. A participle and a substantive (or pronoun) joined together and standing by themselves, independent of the rest of the sentence, are usually both put in the ablative case—*e.g.*, The city having been captured, Cæsar withdrew = *urbe capta, Cæsar se recepit.* These things being finished, the king entered the temple = *his confectis, rex in templum intravit.*

In either of these two sentences, the two words in the ablative could be omitted without impairing the grammatical completeness of the sentence: without them we should still have complete sentences, "Cæsar withdrew," "The king entered the temple." Therefore, the words in the ablative are *absolute*—*i.e.*, independent. But in a sentence like this, "The city, having been captured, was burnt," we could not remove the words "the city having been captured" without ruining the sentence. Therefore, this is not "absolute," and "city" is nominative to "was burnt" (*urbs capta* [nominative] *incensa est*).

So the *ablative absolute* cannot be used if the person denoted by its substantive is either the subject of the principal verb of the clause (as in the sentence just given) or the object (as, "Cæsar having taken the city, burnt it" = *Cæsar captam urbem incendit*—*i.e.*, Cæsar burnt the taken city).

Other examples of the ablative absolute:

Regnante Victoria = in the reign of Victoria (literally "Victoria reigning").

Nullo respondente = no one replying.

His auditis = having heard, or, hearing this (literally "these things having been heard").

Often with adjective instead of participle:

Me invito = against my will (I being unwilling).

Te duce = under your leadership (you being leader).

Me auctore = at my suggestion (I being adviser).

Salvis legibus = without breaking the laws (the laws being sound).

Te non adjuvante = without your assistance (you not assisting).

But do not say *rege pervento*, the king having arrived. There is no passive to an intransitive verb.

SENTENCES TO BE TURNED INTO LATIN.

(Do not consult the key until you have done the work.)

1. Who was the first to hear about the death of Cæsar (say, "Who first heard about dead Cæsar?" The Romans avoided abstract nouns where possible, and used participles instead—*e.g.*, the capture of the city = *urbs capta* = the captured city)?

2. The war against the Africani having been finished (*conficio, confeci, confectum*), the soldiers returned home to Britain (return = *redeo, redivi, reditum*).

3. Our native land was conquered by the Normans in the year 1066 after the birth of Christ (say, "After the born Christ," *post Christum natum*).

4. There is no doubt that (*non est dubium quin*, with subjunctive) the sun is larger than the moon.

5. He is too brave to fear death (say, he is braver than that [*ut*] he may fear death).

6. Before us are two paths: the one leads to poverty and right, the other to wealth and shame: I ask you which of the two you choose. ("You choose" must be subjunctive, because it is in an indirect question—*i.e.*, it depends on the main verb "I ask.")

7. Be thou faithful unto death, and I will give thee a crown of life.

8. The great Bruce, having watched the spider in the cave, resolved to be *of good courage* (*bono animo*, ablative of quality).

Key to Preceding.

1. Quis primus de mortuo Cæsare audivit ?
2. Bello contra Africanos confecto, milites domum in Britanniam rediverunt.
3. Patria nostra a Normannis anno millesimo sexagesimo sexto post Christum natum superata est.
4. Non est dubium quin sol sit major quam lună (nom.), or lunā (ablative, without quam).
5. Fortior est quam qui *or* ut mortem timeat.
6. Ante nos sunt duæ viæ : altera ad paupertatem et honesta (acc. neut. plu., honourable things), altera ad divitias et dedecus ducit : rogo utram deligatis.
7. Esto fidelis usque ad mortem, et dabo tibi coronam vitæ.
8. Ille Brutius, quum araneam in antro observavisset, esse bono animo constituit.

Section III. TRANSLATION.

(The numbers at side of words indicate the order in which the words are to be taken : note them carefully. The letters in brackets refer to the notes at the end.)

"Cæsar's First Landing in Britain."

Quod (*a*)[4] ubi[1] Cæsar[2] animadvertit,[3] naves (*b*)[7] longas,[6] quarum[8] et[9] species[10] erat[11] barbaris[13] inusitatior,[12] et[14] motus[15] ad[17] usum[18] expeditior,[16] paulum[20] removeri[19] ab[21] onerariis[22] navibus,[23] et[24] remis[26] incitari,[25] atque[27] inde[28] fundis[33], sagittis,[34] tormentis,[35] hostes[29] propelli[30] ac[31] submoveri[32] jussit.[5] Quæ[1] res[2] magno[4] usui[5] nostris[6] fuit.[3] Nam,[1] et[3] navium[5] figura,[4] et[6] remorum[8] motu,[7] et[9] inusitato[10] genere[11] tormentorum[12] permoti (*c*).[2] barbari[13] constiterunt (*d*)[14] ac[15] paulum[17] modo[16] pedem[19] retulerunt (*e*).[18] Atque,[1] nostris[2] militibus[3] cunctantibus (*f*),[4] maxime[5] propter[6] altitudinem[7] maris,[8] qui (*g*)[9] decimæ[12] legionis[13] aquilam[11] ferebat,[10] contestatus (*h*)[14] Deos,[15] ut[16] ea[17] res[18] legioni[21] feliciter[20] eveniret[19]: "Desilite"[1] inquit,[2] "commilitones,[3] nisi[4] vultis (*i*)[5] aquilam[7] hostibus[8] prodere[6]: ego[9] certe[10] meum[12] reipublicæ[14] (from respublica) atque[15] imperatori[16] officium[13] præstitero" (*k*)[11]. Hoc[3] cum (*l*)[1] magna[4] voce[5] dixisset.[2] ex[8] navi[9] se[7] projecit (*m*)[6], atque[10] in[14] hostes[15] aquilam[13] ferre[12] cœpit.[11] (From Cæsar, De Bello Gallico, Book IV, chap. 25.)

Notes. (*a*) Quod : acc. of qui, governed by *animadvertit.* We say, "When Cæsar perceived this" ; the Romans said, "Which thing when Cæsar perceived."

(*b*) Navis longa = a ship of war.

(*c*) Permoti (from permoveo), is nom. pl. of perf. participle passive, agreeing with *barbari.* "The barbarians, having been influenced by the shape of the ships," etc. *Figura, motu* and *genere* are abl. after *Permoti.*

(*d*) Perfect of *consisto.*

(*e*) Perfect of *refero.*

(*f*) Ablative absolute.

(*g*) Qui = he who.

(*h*) Contestatus = calling to witness (though passive in form, it is active in meaning).

(*i*) Second pl. pres. indic. from *volo,* I wish.

(*k*) Fut. perf. of præsto, I discharge.

(*l*) Cum is another form of *quum,* when.

(*m*) Perfect of *projicio.*

Key to Above Passage.

"When Cæsar perceived this, he ordered the ships of war (of which both the appearance was more novel to the barbarians, and whose movement was quicker for use, to be moved a little from the vessels of burden—*i.e.*, transports—and to be urged forward by oars, and then the enemy to be driven back and dislodged by slings, arrows, and engines. This thing was (for) a great advantage to our (men). For, having been influenced both by the shape of the ships and by the motion of the oars and by the unusual kind of engines, the barbarians halted, and drew back (their foot) a little. And, as our men were hesitating, mostly on account of the depth of the sea, he who carried the Eagle (standard) of the 10th legion, calling the gods to witness that that thing would turn out luckily for the legion, says, 'Leap down, fellow-soldiers, unless you wish to hand over the eagle to the foe. I, at any rate, will have discharged my duty to the republic and to the general.' When he had said this with a loud voice, he threw himself from the ship and began to carry the eagle against the foe."

To be continued

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PRONOUNS—continued

2. Demonstrative Pronouns. *This* and *that,* with their plurals, *these* and *those.*

When used with nouns, they are demonstrative *adjectives* [see last Lesson], as : "these sheep." But when used as nouns—*i.e.*, without being joined to a noun or requiring a noun to be understood, they are pronouns, as in the following instances :

a. When used to prevent repetition of preceding noun, as : "The army of Germany is larger than *that* of France."

b. When *this* and *that* = the one . . . the other — *this* referring to the last-mentioned thing, *that* to the first mentioned, as : "We offer you either war or peace : this means prosperity, that destruction."

3. Interrogative Pronouns. *Who, what, which,* and *whether.*

These are used in asking questions, either direct questions, as : Who is there ?, or indirect—*i.e.*, questions depending on a previous verb, as : "He asked who was there."

Who, which, and *what,* are also used as relative

pronouns [see next Section], but they were originally interrogatives.

Who is thus declined:

Singular and Plural

Nominative	Who (Anglo-Saxon *hwa*)
Objective	Whom
Possessive	Whose

Which and *what* are indeclinable. *What* is the neuter of *who* (*cf.*, *it*, *that*). *Which* = *hwi lic* ("who like," *hwi* being the old instrumental case of *hwa*). *Whether* means "which of the two?" (*who-ther*).

Who is used with reference to persons only, never to things: it is always a substantive. *Which* and *what* are used both substantively and adjectively—*e.g.*, "What did you go out to see?" (substantively); "What sneaking fellow comes yonder?" (adjectively); "Which was the braver?" (substantively); "Which way went the Spirit of the Lord?" (adjectively).

Who and *what* ask perfectly indefinitely: *which* asks for one out of a selected class or group. *What* is neuter when used as a substantive.

What (interrogative) is often used in exclamations, as: "What dreadful sufferings, with what patience, he endured!" (Charles Lamb). It is sometimes used adverbially = why?—*e.g.*, "What should I stay?"; "What need we any spur?"

Whether as an interrogative pronoun must be carefully distinguished from the conjunction—*e.g.*, "He asked whether you were in" (conjunction); "Whether of the twain will ye that I release unto you?" (pronoun).

4. Relative Pronouns. *That*, *who*, *what*, *which*. Almost all the pronouns "relate" to some previous noun, but these "relative pronouns" also connect the clause which they introduce with the former part of the sentence. In the sentence just written, for example, *which* is a relative pronoun referring to "clause" (called the *antecedent*), and connecting the clause "which they introduce" with the earlier part of the sentence.

Relative pronouns, therefore, introduce sentences which are *adjectival* to some noun or pronoun in another sentence, for in the above, the sentence "which they introduce" limits or qualifies the meaning of "the clause," and is therefore adjectival.

If we examine any sentence containing a relative pronoun—*e.g.*, "He whom thou lovest is sick," we see that but for the use of the relative, the sentence must have been broken up into two separate parts: "He is sick: and thou lovest him." This is true of no other pronoun, so that a relative pronoun is really a pronoun and conjunction combined. (This is seen very clearly in Latin: the Latin idiom for "I sent my slave *in order that he* might tell you" is, "I sent my slave *who* might tell you," and for "and when he had done *it*," Latin says "*which* when he had done.")

That is our oldest relative. As a relative, it is always a substantive, and may refer to either persons or things; it is also indeclinable—*e.g.*, "This is the house *that* Jack built." "Mark but my fall, and that *that* ruined me." It cannot always be used for *who*; we cannot say: "My father that is an old man." It is used for *who* or *which* only when the antecedent is incomplete and requires further definition—*e.g.*, "Blessed are they that mourn," "All is not gold that glitters." [Note. *That* may be (1) conjunction, (2) demonstrative adjective, (3) noun, (4) relative pronoun, (5) demonstrative pronoun. In the following sentence, "that" illustrates each of these parts of speech in the order named: "He said that that 'that' that the boy had written was that of a bad writer."]

Who passed from the stage of an interrogative pronoun to that of an indefinite pronoun, meaning "any one" (*cf.* the expression: "As who should say"). It then became an indefinite relative by the addition of -soever, and finally became an ordinary relative, the -soever being dropped. It is declined like the interrogative.

"Who" and "whom" are now used only of persons, but the possessive "whose" can be used even of lifeless things—*e.g.*, "Nebuchadnezzar made an image of gold whose height was threescore cubits" (Daniel).

What is used only of things, and never relates to any antecedent except *that* (which is always understood and never expressed); it is therefore used in the singular only. "What all desire, must be good"—*i.e.*, "that which all desire, etc." There are instances of the relative *what* used as an adjective, but they should not be copied—*e.g.*, "What time I am afraid, I will trust in Thee" (Psalms). *What* used to have other words as antecedents, but nowadays it is incorrect to say: "The man what said it, is dead."

Which is the ordinary relative referring to animals or things, as *who* to persons. It was formerly used of persons as well—*e.g.*, "Our Father which art in heaven." In the English Bible it is often preceded by "the"—*e.g.*, "In the which ye also walked." It differs from *who* in that it can be used as an adjective—*e.g.*, "which things have indeed a show of wisdom" (Colossians). "Who" and "which" can always be used where "that" (relative) is used, though, as we have seen above, the converse is not true. "Of which," "by which," "in which," etc., are sometimes written "whereof," "whereby," "wherein." Similarly "thereof" = "of this," or "of it."

Who, *which*, and *what* may each be compounded with *-ever* and *-soever*, and *who* may also be compounded with *-so* (whoso). The forms in *-so* and *-soever* are not often used now. "Whosoever" is declined—nom., whosoever; obj., whomsoever; pos., whosesoever.

Rules of Relative and Antecedent. A. A relative pronoun must have an antecedent, expressed or understood. This may be a noun, a pronoun, a noun-phrase, or a noun-clause. The antecedent of *who* and *that* is sometimes understood—*e.g.*:

" . . . Who reads Incessantly, and to his reading brings not A spirit and judgment

equal or superior . . . Uncertain and unsettled still remains." ("Paradise Regained.")

(Here "he" is understood before "who.")

"That thou doest, do quickly." (Here *that* = "the thing which.")

B. The relative agrees with its antecedent in number, gender, and person; but its *case* is determined by its own clause—*e.g.*, "I, *who* erewhile the happy garden sung" (*who* is first person, singular, masculine, agreeing with antecedent "I"; its case is determined by its own clause, it being nominative because subject to "sung").

"Those (nom.) whom (obj.) the gods love die early" (*whom* is plural, common gender, agreeing with *those*; but it does not agree with "those" in case, being objective after "love").

"To those who ask how kind thou art" (here *those* is objective and *who* nominative).

Important Note: *Who*, both as relative and interrogative, presents endless difficulties to "the man in the street," and there are comparatively few Englishmen who are always sound in their grammar on this point. Even the Authorised Version of the Bible breaks down here, a very rare thing indeed. In Mark viii. 27, we read: "Whom do men say that I am?" This, of course, should be "who," as we see if we alter the form of the sentence: "Who am I, do men say?" If we keep "whom," we must say: "Whom do men think me to be?" All such expressions as "Who did you see?" "Who did you speak to?" "I know who you mean," "The man who I saw" should be avoided.

Omission of the Relative. The relative is often omitted, but only when if expressed it would be in the objective case—*e.g.*, "The thrifty hire I saved under your father" ("As You Like It"), where "which" is understood. This is very common in colloquial English: "The book he gave me is lost." It is said, however, that in the English Bible the relative is not once omitted.

We sometimes omit a preposition as well as a relative, as: "the way he walks" (for "the way in which he walks"). This is very slipshod.

The relative should never be omitted—

a. When, if expressed, it would be in the nominativ .

b. When th relative sentence, instead of defining or restricting the antecedent, states some further circumstance attending the antecedent, and is continuative or ampliative rather than restrictive. If we compare the two sentences: (1) "He broke the pen which I lent him," (2) "His eldest son, whom he had lost many years before, had always been his favourite," we see the difference. In (1) *which* defines limits, restricts the meaning of *pen*; in (2) *whom* amplifies and enlarges on "his eldest son."

The *which* in the first sentence could be omitted, but *whom* in the second could no be left ou .

"*Than whom.*" For some unknown reason, the relative is always put in the objective after "than," even in cases where any other pronoun would be in the nominative—*e.g.*, "Which when B elzebub perceived, than whom, Satan except, none higher sat, with grave aspect he rose." ("Paradise Lost.")

As is often used as a relative pronoun, after "same" and "such"—*e.g.*, "This is the same as that," "'Tis still a dream, or else such stuff as madmen tongue" ("Cymbeline").

In old English the genuine relative was used after *such*—*e.* .,

"Such an enemy
Is risen to invade us, *who* no l ss
Threatens than our expulsion down to Hell!"
(Milton.)

As *such* meant "so-like," *which*, meaning "what-like," naturally followed it; and so with the other relatives, "who" and "that."

5. Indefinite Pronouns. *One, none, aught, naught, any, other, another, some.*

One: a. Adjectively, meaning "some," "a certain," as: "I shall one day perish."

b. Substantively, meaning "a certain person," as: "One in a certain place testifieth" (Hebrews). It is often used in the plural, as: "I have also called my mighty ones" (Isaiah). It is also used like the French *on* and the German *man*: "One can never say what will happen."

None is used for *no* when the noun is omitted, as: " . . . those kindnesses that I have done for you. I know of none."

Aught is from the Anglo-Saxon *a* = ever, and *wiht* = thing. *Naught* is its negative (sometimes spelt "nought"), and *not* is a contracted form of this. They are n t often used now, "anything" and "nothing" usually take their places.

Any is derived from ne, and was originally spelled *ony*.

Other means "one of two." (*cf.* the *-ther* in "whether"). It is used as an adjective and as a pronoun; in the latter case it is declined:

	Singular.	*Plural.*
Nom. and Obj.	other	others
Poss.	other's	others'

"The one . . . the other" are used when only two are spoken of; "one . . . another" when more than two. Similarly, the expression "one another" is not correct when used of only two persons: we should then use "ea h other."

6. Distributive Pronouns. *Each, every, either, neither.*

Each denotes all taken separately; it can be either adjective or pronoun—*e.g.*, "Each morning sees some task begun" (adjective); "The kings sat, each on his throne" (pronoun).

In the phrase "each other" the two pronouns

were originally independent, but the two words are now treated as a compound. Strictly speaking, in the sentence, "They killed each other," *each* is nominative, and *other* objective ("they killed, each killing the other").

EVERY (ever-each) is very similar to *each*. It is usually an adjective ("every man to his tent"), though originally it stood as a pronoun by itself.

EITHER; NEITHER = one of the two (but not both); not one of the two. "Either" and "Neither" should be used only when there are two alternatives: "either of the three" is wrong.

Each, every, either, neither should be followed by a singular verb, as they are always singular —*e.g.*, "Each man knows what suits himself."

EXERCISE ON PRONOUNS.

1. In the following passage pick out and classify all the pronouns:

"There was once a dog who was crossing a bridge, carrying a bone in his mouth. Looking into the water, he saw another dog, that also had a bone in his mouth. 'I should like that,' he thought to himself, 'better than this.' So he dropped his own bone to seize the other, and lost them both. Who could believe that any dog could be so foolish as he?"

2. Correct the following sentences:

a. Who is there? It is me.
b. Let each esteem other better than themselves.
c. I have a brother is condemned to death.
d. I won't say who I mean.
e. Everybody has their faults.

KEY TO EXERCISES ON PAGE 447.

Faulty sentences:

1. Omit "the rest."
2. "Best" should be "the better."
3. Omit the second "a."
4. If one man fills both these offices, this is correct; otherwise insert "the" before "Treasurer."
5. Insert "other" before "poet."
6. Insert "a" before "green."

VERBS.

A verb is a word which says something about a person or thing, or groups of persons or things —as "time *flies*," "dogs *bark*." It was called verb (Latin *verbum* = a word) because it is the most important word in a sentence.

Every grammatical sentence must contain at least two words, the one naming a person or thing (or groups of persons or things), the other telling us with regard to the first that it does something, or is in some state, or has something done to it. The first is a noun and is called the Subject, the second is a verb and is called the Predicate.

TRANSITIVE AND INTRANSITIVE VERBS.

1. A transitive verb (Latin *transire* = to go across) is a verb of action which affects an object; the action "goes across" from the doer to someone or something else. Therefore every transitive verb must have an object—*e.g.*, "*Fear* God: *honour* the king," "The captive *broke* his chains."

2. An intransitive (or neuter) verb cannot affect an object; it denotes a state or condition, or an action confined to the doer—*e.g.*, "Men die," "The top spins."

Many transitive, verbs are sometimes used intransitively—*e.g.*, "He *burst* his chains" (trans.), and "The bubble *burst*" (intrans.), "He *cut* his finger" and "This knife *cuts* well."

Transitive verbs can be used reflexively, with the reflexive pronoun either expressed or understood—*e.g.*, "He *wounded* himself," "Planets *move* (themselves) round the sun."

INFLEXIONS OF VERBS.

Voice. There are two Voices, Active and Passive. A verb is in the Active Voice when its subject stands for the *doer* of the action. A verb is in the Passive Voice when its subject stands for the *object* of the action. Examples: "I *killed* Cock Robin" (active); "Cock Robin *was killed* by me" (passive). In these two sentences the same action is expressed—*viz.*, that of killing; but whereas "Cock Robin" is object in the first sentence, it is the subject (grammatically) of the second.

Intransitive verbs have no passive voice, as they pass over no action to an object.

The Passive Voice is formed by prefixing to the past participle of a transitive verb the different tenses of the verb "to be"—as, "I shall be *praised*," "Thrice was I *beaten* with rods." Be sure, however, that the past participle is that of a transitive verb; if it is that of an intransitive verb, the voice is active, not passive—*e.g.*, "He *is* dead," "I *am* come." We could equally well say, "He *has* died," and "I *have* come."

Mood. When a verb makes a direct statement or asks a direct question, we say it is in the *Indicative* Mood (Lat. *indicare* = to point out). When a verb conveys a command it is said to be in the *Imperative* Mood (Lat. *imperare* = to command). When we wish to express, not so much a fact (in which case we should use the Indicative) as our conception of the fact, we are said to use the *Subjunctive* Mood. These are the three Finite Moods, called "finite" because the action or state denoted by them is "limited" by considerations of number, person, and time.

There is a fourth Mood, the *Infinitive*, in which the notion expressed by the verb is absolutely "infinite," unlimited by number, person, or time—*e.g.*, "I cannot *speak* for tears" (*i.e.*, "I am not able *to speak*"). Some grammarians deny that this is a "Mood" at all.

To be continued

[*Further instalments of the French and German Courses appear in Part* 5 *of the* SELF-EDUCATOR.]

HOUSEKEEPING AND FOOD SUPPLY

A COMPREHENSIVE TREATMENT OF HOME MANAGEMENT AND ALLIED SUBJECTS

SERVANTS

Position and Duties of all Domestic Servants of Both Sexes. Mistress and Servant Law

COOKERY AND LAUNDRY-WORK

A Practical Course of Cookery, embracing the Preparation of all Foods, with Recipes; followed by a thorough treatise on Laundry-work.

FOODS AND BEVERAGES

Bread and Biscuit Making. Confectionery. Sugar. Fruits for Preserving. Brewing. Malting and Distilling. Mineral Waters. Wines. Tea, Coffee and Cocoa. Fishing and Fisheries. Food Preservation. Cold Storage

WITH

A PRACTICAL COURSE IN CATERING, THE MANAGEMENT OF RESTAURANTS AND HOTELS

BY

A. EUNICE T. BIGGS, County Council Lecturer on Health and Home Management
CLAYTON BEADLE, Analytical Chemist; Lecturer before the Polytechnics; and others

QUALITIES OF GOOD SERVANTS AND SERVANT LAW

By A. Eunice T. Biggs

A SERVANT has been defined as "a person who is subject to the command of his master as to the manner in which he shall do his work," and such a person becomes a domestic or menial servant when he "lives in his master's house and attends to the personal wants and pleasures of the master or his household."

At present there exist several means of obtaining domestic servants, all more or less unsatisfactory. As a general rule the master, or more commonly the mistress, has recourse to a registry office. Here she registers her wants—the kind of servant she is seeking, giving full particulars of the age, salary offered and duties to be performed by the person engaged. These details are recorded by the keeper of the registry-office, whose duty it now becomes, on the payment of a fee, to place the would-be mistress in communication with suitable servants, disengaged at the time, who have also registered their names as persons seeking such employment. The servants who place their names on the books at a registry-office are often not required to pay a fee, or, at all events, they may defer the payment until after they have been "suited" with a situation.

The Engagement. During recent years abuses have arisen in connection with the keeping of registry-offices. They have frequently been conducted by unscrupulous persons who pocket the fees of the mistresses and servants who have believed their promises, and then make not the slightest effort to suit either class of applicant. In other cases incompetent, dishonest, and generally unsatisfactory servants are sent to mistresses seeking servants: the result being considerable discomfort and annoyance to both parties.

Lately an effort has been made to establish registry-offices on a more businesslike basis. Properly qualified persons competent to ascertain and judge of the qualifications of intending servants, and supported in their endeavour by the co-operation of mistresses, are now undertaking the work of bringing into communication the intending employer and the servant whose character and competence bear close investigation.

The Registry-office. Failing the assistance of the registry-office, both mistress and servant must endeavour, by advertisement in a daily newspaper, to obtain the desired end. But the disadvantage of such a method is obvious. It is troublesome to a mistress, since in answer to her advertisement she will probably get numerous letters from illiterate persons, many of them quite incapable of executing the duties of the post offered, or of stating their qualifications and experience clearly and with accuracy. On the other hand, the mistress who answers advertisements purporting to be those inserted in the newspaper by servants requiring work, will find that, in most cases, such advertisements emanate from registry-offices, and are merely baits to ensnare the unwary and secure a fee.

Thus it will be seen that at the present time the means by which servants and mistresses can get into communication with each other are in a very unsatisfactory state. It is therefore to be hoped that during the next few years the attempts now being made to place matters on a more satisfactory and legal basis will meet with success, and so obviate much of the annoyance at present experienced by both parties concerned.

Desirable Characteristics. The comfort of a household is indissolubly associated with the character and competence of the domestic servant. This being the case, it is not surprising that the mistress attaches the greatest importance

to the evidence of the past career of the servant she engages. It is a serious matter to introduce into a household a person of whom little is known, whose previous service will not bear full investigation, or who cannot produce evidence of good character and a certain amount of skill from those with whom he or she has been previously associated.

In engaging a servant the mistress should be on the look-out for certain moral characteristics which are most important. On the other hand, those who wish for success in the capacity of domestic servant will do well to consider the value of such qualities and endeavour to acquire and exercise them.

Cleanliness of person and habits of neatness and method in general cannot be overrated. An untidy, slovenly cook, working unmethodically in a dirty, ill-kept kitchen, affords an object-lesson of what unsatisfactory domestic service may be. Good work cannot be done without neatness and method, and untidy habits and uncleanly utensils double the work of the servant and naturally give much annoyance to the mistress. Personal neatness is also of great importance. The neat print dress and cap and apron of the maidservant and the livery of the manservant, if properly cared for, contribute greatly to their satisfactory appearance; and with due attention to such details as neat hair, personal cleanliness, etc., the dress of the domestic servant is at once becoming, suitable, and by no means unattractive.

A Code of Honour. Characteristics which are, of course, indispensable to a domestic servant are honesty and truthfulness. It is of supreme importance that the mistress should be able to trust the servant she engages. The relationship between mistress and servant is very personal in its character, and the servant will have countless opportunities, not only of defrauding the mistress, but also of displaying strong moral character and trustworthiness. Temptation to appropriate the employer's goods is pretty sure to occur—in fact, is almost unavoidable, and the comfort of the mistress will depend to a very large extent on the degree of confidence she can place in her servant. She should be able to trust implicitly in her servant's word, and know beyond all doubt that the servant will not abuse the confidence so entrusted. Many servants who are absolutely reliable where money, jewellery, or such-like valuable matters are concerned, are not irreproachable with respect to food, notepaper, and other small matters. To read an employer's private letters, to be over-curious as to the mistress's private affairs—these are characteristics which should not be found in a desirable servant. The servant who has the highest standard of honour will treat his or her master's goods with the economy and respect he would use towards his own possessions. A dishonest servant creates discord in a household; suspicion is awakened and the spirit of generosity and confidence which makes for happiness is entirely lost.

Good temper and willing service are very desirable in a servant. Grudging service loses half its value, and a bad-tempered servant will be tempted to disrespect and discourtesy. A cheerful demeanour and obliging manner lend a charm to all service that cannot be overrated, and in adding to her mistress's comfort the servant secures her own happiness.

Good health is a desirable asset from the servant's point of view. A delicate person cannot perform his duties satisfactorily, and the attempt leads to much discomfort to both himself and his employer. Domestic service demands good health as a first essential, and is not suitable except for those who are well equipped for it by a liberal endowment of health and strength.

The Value of Punctuality. Punctuality is another important characteristic of a good servant, and, we may safely add, of a good mistress also. The characteristics of a good master and mistress and their duties towards their domestic servants we shall, however, consider carefully later. A servant should endeavour, for her own sake as well as for the sake of others, to cultivate habits of punctual rising. The peace of many a household has been lost by the irritating delay of a late breakfast or an unpunctual dinner. Nothing is so wearing to the temper, or so trying to the patience, as unpunctuality in the domestic service. Mistresses will do well to remember that the punctuality of the servants depends to a large extent on themselves, and that an unpunctual mistress makes an unpunctual servant.

Lastly, the servant must bear in mind that an essential duty is obedience and loyality to the master and mistress. The servant has no right to consider whether the order given is unreasonable or inconvenient. It must be executed, provided it is lawful, and within the scope of the servant's employment. Refusal to obey justifiable orders may give cause for "immediate dismissal," which we shall consider in detail later in this course. The servant should exercise forbearance and restraint in speaking of the master or mistress to fellow-servants or other persons. The talking over of a grievance often magnifies it to an alarming degree, and much may be said in haste that will be repented of at leisure. A loyal servant will not allow himself to belittle any member of the household, but will as far as possible identify his interests with theirs.

A respectful manner towards an employer is very desirable, and a servant will do well to cultivate habits of politeness both in speech and action. There is a great distinction between respect and servility, and in giving due respect to master or mistress the servant does no violence to his own independence and proper pride.

The Giving of Testimonials. In order to protect a mistress when engaging a new servant, it is customary for a written statement called "a character" to be given by a previous employer. A mistress is, however, under no legal obligation to give the servant a character. It is, nevertheless, customary to

do so, and refusal is generally very prejudicial to the servant concerned, implying, as it does, that the late employer is unable to testify to his good qualities. If a mistress consents to give a character, she must be careful to state the truth, and nothing but the truth. There must be no exaggeration either of the servant's qualities or imperfections. The "reference" should be an unprejudiced statement of the servant's characteristics, and should give a correct impression of the servant's abilities. Such a statement so made, whether by word of mouth or in writing, is held in law as "a privileged communication," and the master making such "privileged communication" does not render himself liable for slander or libel. This security of the master holds good even if the statements made in giving the "character" be untrue, unless it can be proved that the statement was made "maliciously."

Privileged Communications. In order to bring successfully an action for libel or slander against a master, the servant must be able to prove not only that the statements made are untrue, but also that they were made "with malice." Should the servant be able to show that the master made certain statements with regard to the servant's character, *knowing them to be untrue*, evidence of malice could be proved. Supposing that a mistress gives a servant on leaving her service a good character, but afterwards ascertains that the servant had forfeited her right to such a testimony of good conduct, the mistress is then justified in communicating with the servant's new employer. Such a communication will also be "privileged," and the new employer may ask questions and be answered by the former mistress.

Thus it is very obvious that in giving a servant a character the greatest care should be taken to make only accurate statements, and to choose carefully the words used in expressing such statements. All trace of exaggeration should be scrupulously avoided. Words should be carefully chosen in giving a character, and particularly in speaking of the servant's shortcomings. In giving such particulars, the mistress should be just, remembering that she should, as far as is compatible with justice, set forth the servant's good qualities, rather than any faults he may have. On the other hand, in justice to the new employer, grave faults should not be concealed, although it is only kindly to set forth to the best possible advantage any qualities and evidences of competence the servant may have shown in the execution of his duty.

The Mistress's Liability. It is not generally known that a master or mistress who wilfully gives a false character incurs a grave liability. Should the new employer incur loss or injury as the result, the mistress giving the false character renders herself liable. If the new employer finds that the servant does not deserve, or in some way forfeits, the good character given previously, the new employer should not allow others to be imposed on by a false character. But the utmost care must be taken, in adding any disparaging remark to such a statement, that nothing but the truth be added, and that *without malice*.

It is an offence against common law to forge a character in order to deceive and obtain a situation by false pretences. Heavy penalties are incurred by those who "falsely personate a master or mistress," or who wilfully make misstatements with regard to length of service, or the capacity in which the servant has been hired; or who alter or efface any word or other detail given in a character by a former master or mistress.

When a Servant may be Dismissed. If a servant is engaged temporarily for some definite period, say a week or a month, no notice need be given her, since she will leave at the expiration of her engagement. In ordinary cases of domestic servants it is customary—and the custom is recognised by law—to give one month's notice, or a month's wage in lieu of notice. In the case of the first month it is sometimes held that the mistress or servant may terminate the engagement by notice given at or before the expiration of the first fortnight. The first month is, in such cases, taken as one of "trial" in the absence of any special agreement to the contrary.

If a domestic servant is guilty of wilful disobedience to a lawful order she renders herself liable to dismissal without notice; but trifling acts of disobedience are not always sufficient to justify such summary dismissal. Misconduct is the most usual cause of his or her dismissal without notice. If a servant be guilty of habitual drunkenness, or drunkenness even on one occasion, which unfits him to execute his duty; if the servant be guilty of immorality, violent conduct, theft, or insolence, instant dismissal is warrantable. Gross and habitual negligence of duties may meet with similar treatment; while a servant who is quite incompetent to perform the duties undertaken may be dismissed without notice, since he cannot perform his part of the contract. Lastly, illness of a permanent nature on the part of the servant justifies the master in dismissing him. But the dismissal must be in definite terms, and the wages up to the date of dismissal paid, otherwise the master will be liable.

When a Servant may Leave without giving Notice. If the mistress denies proper food to the servant, or exposes the servant to unnecessary risk, the servant may leave her situation at once. Also if infectious disease breaks out in a house, the servant may (but there may be exceptions to this) leave without giving notice. If the servant leaves her situation in this way, and is justified in doing so, she may claim her wages up to that date, and may also be awarded damages.

The whole question of the legal relationship between servant and employer is of the utmost importance, and should be studied with the greatest attention. Once it is thoroughly grasped, we may proceed to study in detail the duties of various domestic servants, and the duty they may reasonably expect an employer to exercise towards them.

It is of the greatest importance that both master and mistress should understand exactly what their duties are towards their domestic servants. For the servant has his or her "rights," and these are no less stringent than those demanded by the master. Consideration of the servant, and proper care of his welfare, will encourage him to serve his employer with the utmost zeal The master will, moreover, enjoy a feeling of satisfaction that cannot be overrated in the knowledge that he has done his duty by those dependent on him. We have already dealt with the qualities most desirable in a servant, and we must now consider the characteristics of a good employer—whether master or mistress—and the duties that are owed to a servant.

A Cause of Dissension. Perhaps it will be well first to notice one chief cause of dissension between mistress and servant. In many households, especially those in which there are many grown-up daughters, the servants, and the maid-servants in particular, are given orders by a variety of persons. This is a mistake to be avoided whenever possible. All sorts of little orders and counter-orders worry the servant and hinder her in the proper execution of her regular duties. And this is not the only disadvantage of such a system. Nothing is less desirable than grudging service, or work that is done with a bad grace. On the other hand, there can be no objection to an occasional request from some member of the family that some special work should be done, and the servant would be sadly wanting in generosity who would object to execute some little additional task which adds to the general comfort of the household. The mistress, for her part, should, as far as possible, endeavour to give her orders first hand. It is the greatest mistake to give an order through another servant when this is avoidable; although, of course, in many cases it is natural and customary.

Characteristics of a Good Mistress. A good mistress exercises an important influence over her servants. If she is energetic, good-tempered, and pleasant to live with, her servants will, as a rule, take their tone from her. A mistress with whom it is difficult to live peaceably will make it difficult for even the most painstaking of servants to serve her satisfactorily. Certain qualities in a mistress are pretty sure to reflect themselves in the servants' conduct; and the mistress who wishes to ensure the highest degree of household happiness will do well to cultivate these qualities.

One of these essential characteristics is punctuality. In a well-organised household there will be fixed hours for every meal and every item of the daily routine. These fixed hours should be rigidly adhered to by every member of the family. The children will take their cue from their elders, and to be late for a meal should be regarded as a grave offence. The household should be aroused at a fixed hour, and breakfast should be served punctually. It is well for the discipline of the kitchen if every member of the family can put in an appearance at the breakfast-table. In middle-class families, and in homes where expenditure has to be carefully considered, much unnecessary waste will be avoided by this punctual breakfasting. Bacon will not get cold or burned, eggs will not get hard and indigestible, and endless relays of fresh tea and coffee will be unnecessary. If the mistress is at all self-indulgent in the matter of lying in bed late in the morning, the whole organisation of the kitchen is bound to suffer. Even a punctual cook will see the futility of serving a meal at its appointed hour, after she has seen the long delay before the food is eaten. The mistress should insist on the punctual serving of each meal, and should personally see that her orders are properly executed. We all know the discomfort of the type of household in which, when seven o'clock dinner is needed, "Cook must be told to have it ready at 6.30 p.m., then it will be on the table by seven!" Such methods at once reveal the fact that something is lacking in mistress as well as in servant.

Useful Habits. Habits of tidiness should always be insisted upon by the mistress, and she should seek to instil the same appreciation of neatness and the same love of order into the younger members of the family. An untidy bedroom gives an infinitude of trouble to the maid who is responsible for sweeping and dusting. In little matters such as these a good mistress will show all possible consideration for her servants, giving no unnecessary trouble, and endeavouring to lighten their duties and make their work pleasant.

In giving her orders for the day, the mistress should state definitely and clearly what her wishes are, otherwise there may be some misunderstanding, leading to difficulties that might have been avoided by the exercise of a little care. Once her orders have been given, the mistress should try to avoid countermanding them. Of course it will sometimes happen that some unusual and unexpected turn of events will cause the change of all her plans. This may necessitate a complete alteration of all the orders she had given for the day. But it is obvious that these departures from routine are worrying to the servant and should be avoided whenever possible.

The Giving of Directions. When a mistress requires some particular service from a servant, she should give her directions firmly and avoid the semblance of making a request. It is quite possible to give an order with absolute politeness and yet with indisputable firmness, and this is the preferable attitude of the mistress towards the servant. Of course a dictatorial tone is most objectionable, but a wavering order that admits of questioning leads to quite as much annoyance. Discussions between mistress and maid should not be tolerated. Familiarity of tone should also be avoided, and both mistress and servant will find that it will answer far better in the long run to maintain an attitude which, though perfectly amiable and friendly, is entirely lacking in familiarity.

This word of warning is very necessary to young wives whose husbands of necessity leave them much alone with maidservants during a long day. The temptation to talk to someone may be very great, and, failing the presence of a friend, the young housewife may find herself embarking on a too familiar conversation with her maid. This is often a mistake. On the other hand, a good mistress will take a real and personal interest in her servants, who will not be afraid to talk quite freely to her, knowing that she will give them ready sympathy, and, if possible, help. Ladies, and especially young ladies, are too prone to make confidants of their maids, and to make them the recipients of information which had far better be withheld. Unless the lady's maid is very trustworthy, she is more than likely to regale her fellow-servants with the confidences she has received, thus bringing about an undesirable state of affairs.

The Danger of Mischief-making. One of the chief causes of dissension in a household where more than one servant is kept is the readiness with which the individual servants find fault with each other to the mistress. This affords the latter an opportunity for exercising the greatest tact. Under no circumstances should the mistress show herself ready to listen to mischief-making remarks. Jealousy or spite are often at the root of the matter, and in any case it will be far wiser for the mistress to be on the alert to detect wrongdoing herself than trust to its discovery by another servant. Matters cannot become very seriously wrong if the mistress is really observant. She should know so thoroughly each item of the daily routine that no little omission will escape her.

We are for the present considering more particularly the attitude of the mistress of a middle-class household, who keeps the reins of household management in her own hands. In a larger *ménage*, where this work is left to a housekeeper, the latter will need to acquire all the qualities that should characterise a good mistress. The housekeeper in such a case represents the mistress, and the servants will depend on her to a very large extent for their welfare and proper control. But whether the responsibility rest with mistress or housekeeper, the essentials are the same.

Necessity for Supervision. The servants should feel that their work is well under supervision; that well executed work will be noticed and meet with reward; and that neglect of duty will be also observed and incur blame. This supervision is particularly necessary with young and inexperienced servants. Their youth gives them but a small sense of responsibility and duty, and their inexperience makes it at times a little difficult for them to carry out their share of the household work satisfactorily. Such young servants will profit greatly if placed for a time under the tuition of an older and really trustworthy maid. In a small household the mistress herself will find it well worth her while to take some trouble and expend a good deal of time in showing her maid how she likes the work done. Then in the future, if the maid is conscientious and intelligent, there will be fewer difficulties to contend with.

Recreation. Lastly, a good mistress will take a really personal interest in the recreations of her servant. She will allow time for adequate rest, and will so arrange household matters that once on Sunday, at least, each servant is given a chance of attending a place of worship. The mistress has no power to insist that any particular service shall be attended, but if kindly and tactful she will endeavour to meet the requirements of each servant. In the matter of recreation and exercise, however, the mistress has a definite duty towards her servants. In the discharge of their daily duties most servants get a good deal of indoor exercise, but this is not sufficient to ensure good health. A short walk in the open air is desirable, if not absolutely essential. In a large establishment, one or two servants can in turn be spared for the purpose; and in a smaller household, where there are fewer servants, or even only one, an opportunity can generally be made by a little contrivance.

Then, in the matter of recreations and pleasures, if a mistress can now and again offer her servants some little treat—a concert or entertainment of some kind—her thoughtfulness will be much appreciated. Again, a mistress can often contribute to a servant's happiness by the loan of magazines and newspapers. In a large household some such literature is generally provided for the servants, and in a smaller house it will be well for the mistress to consider her servants in this way.

The Characteristics of a Good Master. In the main, those qualities mentioned as essential to a good mistress are as desirable for a master. In a small house, where only maidservants are kept, the master will have few orders to give, and will have little to do with the management of the household. In giving orders a good master will show consideration and politeness when addressing the maidservants, and at the same time avoid all semblance of familiarity. The master should be careful not to run counter to any orders previously given by the mistress, and he should endeavour, as far as possible, to avoid any interference with the mistress's wishes. Lastly, every member of the household should remember that matters of a family, personal, or private character should never be discussed in the presence of servants. And in the same way all disagreements and all suggestion of quarrelling or ill-temper should be hidden from the servants. To witness a "scene" is bad for both parties concerned, since it undermines all feeling of respect and authority.

Food and Lodging. It is the master's duty to supply food to his domestic servants. This right is secured to the servant by law, and the servant has a right to demand adequate food and suitable lodging. In most households the meal-times and the actual food served to the servants differ slightly from that supplied to the members of the family. This difference in the time of serving meals is more convenient, and the difference in food is also advisable. Servants are generally called upon to do a good deal of

work which involves muscular exercise. Thus flesh-forming foods are necessary.

In a large household the servants usually breakfast about an hour earlier than the family. This leaves them free to prepare the breakfast and have everything in readiness at the appointed hour. In order that the house may be comfortable, and some of the rooms cleaned and dusted before breakfast, it is necessary for most of the servants to rise in good time. They are therefore glad of an early meal. When the family are at breakfast, the maids responsible for the bedrooms will throw back the bedclothes, stripping the beds so that they may air well before remaking. In many houses a light lunch of bread and cheese is provided about eleven o'clock for those servants who desire it, and at about one o'clock a substantial middle-day dinner is served. In households where there are young children this dinner will coincide with that of the nursery.

Meals. Between 4 and 5.30 tea of the "school-room" type will be served, including bread-and-butter, and sometimes jam or cake. Then, in the evening, after the late dinner of the household is served, the servants take their last meal—supper. The character of this meal varies considerably in different classes of household. In a large home it is fairly elaborate, and in a smaller one may merely involve a cup of cocoa and bread-and-butter, or cheese. If many servants have to be catered for the supply of food must be carefully checked or there will be unnecessary waste. In such cases the system of "allowancing" is employed, and a definite quantity of tea, sugar, etc., given out from the stores each week. This will be left in the hands of the housekeeper, or the mistress herself will supervise the matter, and we shall consider the question in detail when we deal with the duties of the housekeeper and cook.

Hours. In the matter of lodging the master has also a duty towards his servant—to provide him, with a properly-equipped bedroom and room in which to take meals. The master must allow certain hours and definite times during which the servant may absent herself. Should she, however, fail to return at night, the master is not compelled to wait up for her beyond a reasonable hour. On the other hand, should a domestic servant absent herself without permission during a whole night, the master is justified in dismissing her without notice. But he must avail himself of the right at once, as soon as the offence has been committed, for he cannot afterwards bring forward that act of disobedience as a ground for dismissing the servant without notice. The mistress is bound in the same way as the master to feed her servants properly and to provide them with suitable lodging. If she is married and living with her husband, he will be responsible for the treatment of the servants—unless it can be shown that he supplied the necessary food, and it was wilfully withheld from the servants by the mistress. In such a case he will be exempt from blame, but the mistress is liable to an action by the servant. Quite apart from the duty involved towards a fellow-creature, a master and mistress will find it essential to their own legal safety to consider carefully their duties to their servants. Should a master or mistress so neglect a servant and withhold from him proper food until he becomes enfeebled and unfit for his duties, and should such a servant die, his death being accelerated by the master's neglect, the master exposes himself to the risk of conviction of manslaughter or even of murder.

Criminal Liability. The obligation of the master to provide adequate food and lodging is emphasised by law. For it is provided by statute that—

"Whosoever being legally liable either as a master or mistress to provide for any servant necessary food, clothing, or lodging, shall wilfully and without lawful excuse refuse or neglect to provide the same so that the life of such servant shall be endangered or the health of such servant shall have been or shall be likely to be permanently injured, shall be guilty of a misdemeanour, and being convicted thereof shall be liable to be kept in penal servitude for any period from three to five years or imprisoned for any period not exceeding two years with or without hard labour."

"Where a master, being legally liable to provide for his servant necessary food, clothing, medical aid, or lodging, wilfully or without lawful excuse refuses or neglects to provide the same whereby the health of the servant is or is likely to be seriously or permanently injured, he shall, on summary conviction, be liable either to pay a penalty not exceeding £20, or to be imprisoned for a term not exceeding six months with or without hard labour."

Clothing. In the matter of clothing, the master is not ordinarily bound to provide his servants with clothing, unless some special agreement to that effect has been made. In some cases a particular livery is given to menservants, and in individual cases it becomes the absolute property of the servant after a certain length of time. In the case of maidservants some mistresses prefer to provide them with dresses of a particular colour and material. In the case of caps and aprons, cuffs and collars, and similar details, the mistress may prefer to choose the particular kind her maids shall wear, and in such cases it is more generous to provide them. The mistress may select a particular kind of apron that is more costly than the one the maid would select were the choice left entirely to her. In small households, where only one or two maids are kept, some mistresses will invest in large and particularly strong housework aprons for wear during the performance of rough and dirty work. Strong gloves should also be provided for the servants to wear when cleaning grates, polishing silver, and on other occasions when without such special protection the hands would become unnecessarily dirty.

Illness. If the servant be laid up with a short illness the master is not justified in dismissing him without notice. If, on the other hand, the servant develops a serious complaint, the master may at once give him notice, paying

his wages up to the date of dismissal. It is not sufficient to send the servant to a hospital. In such a case the master is liable for the servant's wages during the time he is ill (unless in the meantime he gives him a week's notice); nor can the master deduct anything from wages to recoup himself for the time that the servant was unable to serve him. The master is not bound, unless he has made a special agreement to that effect, to supply his servant with medical attendance. If, however, when the servant falls ill, the master calls in his own medical man, he will be liable for the fees incurred, and he cannot deduct them from the servant's wages except by the acquiescence of the servant in question.

Board Wages. If for any reason it becomes necessary for the servant or servants to be left at home while the rest of the family are away, it is usual to place them on what are termed board wages. This is a sum of money paid in addition to ordinary wages, and intended to be spent on the food and other necessaries to which the servant would be entitled if the master were at home. The actual sum paid will vary according to the style of household in which the servant is engaged, and it will also vary with the sex of the servant for whom such provision is being made. Thus, a minimum sum paid to a maidservant as board wages would be 10s. a week in addition to her ordinary wages, the amount being increased in a wealthier establishment, or when paid to a manservant.

In a large household where many servants are left on board wages, each will be paid his or her allowance individually, but as a general rule the servants will add the small independent sums together for current expenses. Under this arrangement, by good management, each servant will live exceedingly well, and a surplus will probably be left over from the total sum of board-wage money, which can then be divided among them. It is a well-known fact that it is always proportionately cheaper and more economical in every way to cater for several persons rather than for one. There need be very little waste, greater variety in the actual food provided is possible, and small initial expenses become infinitesimal when shared by several, whereas such expenses amount up to an alarming total when met by one person alone.

Alternative Methods. Occasionally a mistress will consider it desirable to dispense with the system of paying board wages, and arrange that the servants shall purchase necessities for themselves at the various shops at which she deals. In this case the accounts for all such commodities will be sent in to the mistress on her return. Such a system does not generally commend itself, and the objections which can be raised to it are obvious.

To begin with, servants generally prefer the board wages. This gives them perfect freedom in the selection of their food, and, moreover, should they be of an economical turn of mind, enables them with perfect honesty to save a small margin of profit on their weekly allowance. The system of arranging for all expenses to be entered in an account has very many disadvantages. The servant feels that each item of expenditure may be examined and criticised by the mistress, who, on the other hand, will probably find the whole system very expensive and unsatisfactory. Of course, providing the servants are reasonably economical and conscientious, the accounts need not be extortionately large; but then, again, the mistress may feel a little uncomfortable lest, through over-conscientiousness, her servants have stinted themselves in her absence. And even the most contented of servants may not be able to resist the feeling that they might have been treated more liberally.

Thrift. A mistress who has her servants' well-being at heart will take care—particularly if her servants be young—to instil into them the idea of the necessity for thrift. A young and inexperienced servant, coming, perhaps, for the first time into service from school and home, has no idea of the most advisable use to which to put her money. Her essential expenses are met for her—food and lodging are already provided for. She has, however, to keep herself well equipped in the matter of clothes; and a certain sum will be essential for travelling expenses, pocket-money, stamps, etc. Many domestic servants have to send regular help to their family, and this considerably lessens the total wage. But every mistress should, as far as possible, urge on her servant the necessity for thrift, and encourage them to set aside at any rate a small proportion of her wages yearly.

Kitchen Etiquette. Kitchen etiquette varies widely in different households, and with the number of servants employed. Where only two or three maids are kept, there will probably be no separate room for the servants' meals, when they will take them together in the kitchen. Their preparation, and the duty of laying the table, will fall to the share of the cook, or of the kitchenmaid should one be kept. If one of the servants is the children's nurse, she will, in all probability, take her meals upstairs in the nursery at the same time. In this case, it will be a matter for the mistress to arrange with her servants at the time of engaging them—whether the nurse is to fetch her meals from the kitchen, or whether they will be brought up to the nursery by one of the servants. It will be well for the mistress to make this point quite clear, for, unless she does so, there may be some friction between the nurse and the other servants, on the ground that they may object to waiting on her as a fellow-servant.

Housekeeper's Room and Servants' Hall. The housekeeper's room is furnished as a sitting-room, and is used by the housekeeper and other servants for their meals. Here the butler, lady's-maid, and valet take their meals with the housekeeper. Should there be guests staying in the house, accompanied by maids, these ladies'-maids will also take their meals in this room. All the other servants presided over by the cook have their meals in the servants' hall, a large room furnished comfortably but plainly as a sitting-room or dining-

room. The servants' hall is generally quite near the kitchen, and is used by them as a sitting-room in the intervals of their duties. In small households there will be no servants' hall, but the kitchen is used instead. Even in a very small establishment an effort should be made to make the servants' room as comfortable as possible. The cheerful surroundings of well-polished saucepan-lids and dish-covers, the neatly arranged dresser and shining range, all contribute an air of comfort to the room.

A thoughtful mistress will make the room still more cosy by providing it with a floor-covering. A square carpet, for instance, is very suitable, if not too large, since it can be taken up during the busiest part of the day when cooking operations are in full swing, and replaced when the servants have practically finished their day's work. Then the table should be furnished with a cloth also, which can be put on one side until the ordinary kitchen routine is over. Every kitchen which serves also as the servants' dining or sitting-room, should be provided with two or three comfortable chairs and a bookcase containing a selection of books. By these simple means, the servants who have met with much consideration, are much more likely to be satisfied with their lot, and to remain faithful in the service of such a mistress.

Smaller Households. The number of servants kept will vary with the position of the master. In a simple ménage, where the income of the master does not exceed £200 a year, one servant only will be kept—a general servant—who will be responsible for all the housework, with the assistance of the mistress, and perhaps that of grown-up daughters also. In some households, a cook and a housemaid will be kept, and with the gradation of income more servants will be employed. In many middle-class households women-servants only are kept, but in larger establishments men retainers are essential. A footboy or page is often kept, in addition to maidservants, where no manservant is kept; and in wealthier households the number of menservants kept will, to a certain extent, be regulated by the number of women-servants. Occasionally, preference is given to additional maidservants instead of menservants; for example, a kitchenmaid may be engaged to assist the cook, her other duties being mainly those which would be performed by a page.

Large Households. In a large household the four chief servants are the housekeeper, the butler, the lady's-maid, and the valet. They take their meals together and their duties bring them more in contact with their master and mistress than the work of any of the other servants. Thus, it is important for these upper servants to be particularly careful in their manner and bearing towards their employers—to be invariably respectful in their presence, and unflinchingly loyal in their absence. These points are of the very greatest importance. The housekeeper has abundant opportunity of influencing the women-servants of the household for good, who will all take their cue from her.

The butler is similarly responsible for the tone prevalent among the menservants. One of his duties will be that of securing faithful service from the under menservants. He must be conscientious and painstaking in the execution of his own duties, for he will find it difficult to obtain satisfactory service for his master from others should he in any way be remiss himself.

In their bearing towards their employers the manner of upper and lower servants should entirely coincide. The most perfect civility and politeness is accepted as an essential characteristic in the execution of duty. The servant should never sit down in the presence of the master or mistress unless expressly told to do so; for example, a mistress may tell her sewing-maid to remain seated while she herself is busy in the room. The servant should also be careful not to offer an opinion unless invited to do so, and never to attempt conversation unless at the instigation of her mistress. If this attention to manner and deportment is observed carefully by the servants the master and mistress will be spared the necessity of making any unpleasant complaint on this score, and the servant will escape the disagreeable necessity of listening to it.

Continued

GEOLOGY. METALS. MINERALS.

A THOROUGH COURSE IN THE SCIENCE OF THE EARTH AND ITS APPLICATIONS

INCLUDING

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THE STORY OF THE MAKING OF THE EARTH

By W. E. Garrett Fisher

GEOLOGY, as its Greek name indicates, is "the science of the earth." It deals with the *structure* and the *history* of the planet on which we live, and with the *natural processes* which have moulded it. It endeavours to show how the world around us may have developed out of the gaseous *nebula*, or fiery haze of clashing atoms, which represents the earliest form in which the materials of the earth can be pictured by the scientific imagination. It teaches us to read the wonderful record which is written in the folds of the rocks and stamped upon the surface of the earth, and so to form an idea of the various stages through which our planet must have passed before it could be the fitting abode of human civilisation. Finally, it enables us to look with the eye of science below the smiling surface of fields and parks, or the sandy desolation of the desert, and to predict the places in which it is likely to be worth while for the miner, the railway engineer, and the well-sinker to begin their operations with a hope of successful results.

The study of geology pre-supposes some knowledge of *geography*, or the superficial features of the earth, which it is the function of the geologist to explain and interpret. It is further necessary to assume an elementary acquaintance with *chemistry* and *physics* when the student begins to inquire into the mineral constituents of the *earth's crust*. The student will obtain these from the special courses on the subjects. But the special charm of this science is that the best place to study it is in the open air, and that the most essential piece of apparatus for the scholar is a good pair of eyes and a strong pair of legs.

The main *laws* of geology can be studied within the range of a holiday walk, though it may be necessary to travel far afield in order to witness their application on a larger scale. We propose in this course of study to set them forth much as an intelligent lad might be able to deduce them from a series of rambles with a practical geologist, saying as little as may be about those branches of the science which can be properly learnt only in a well-equipped laboratory and under the direct supervision of a teacher.

The Geologist's Walk. The first thing which strikes the would-be geologist with open eyes, in the course of such a country ramble as forms the best introduction to this science, is that the *features* of the earth's surface always differ, and yet are always recurring. Every turn in the road introduces a slightly different *landscape*, which, nevertheless, depends for its formation on a comparatively small number of details variously combined. The study of these details, with their unison in the several types of scenery, is the subject-matter of *Descriptive Geology*. The study of the natural processes which modify them is the subject-matter of *Physical Geology*, and the study of the changes through which they have come to exist in their present form is the subject-matter of *Historical Geology*. All the numerous sub-divisions which learned inventors of names have suggested come under one or other of these main classes. We can, in short, study only the present and the past—what is, and how it has come to be.

First of all, our pedestrian will notice a difference in the *materials* of which the earth's

surface is composed. He starts his walk on the street pavement, we will suppose, which is made of granite blocks, or of flagstones, which may be composed of compacted sand or the shells of very ancient sea-creatures, of asphalt, or concrete, or some other material which man finds it convenient to walk on. As the streets merge into the country, perhaps this pavement changes into a path of cinders or compacted earth, until it disappears altogether, and our pedestrian is stretching his legs on the macadam of the roadway, which he can easily see to be made up in a different fashion of small fragments of stone closely packed together—and too often coated with their *detritus* in the shape of dust and mud. All these materials, however, do not present the natural surface, but only what has replaced it at the bidding and for the convenience of man. Thus, the urban geologist learns—as his first lesson—that the crust of the earth has been modified in parts by the existence of life.

Soon we leave the road and follow a footpath through the fields. Here the variety of materials composing the earth's crust is still better illustrated. One field is *sandy*, another of heavy *clay*, another of that admirable *loam* which is a mixture of the two. The path leads through a little copse, and we notice the rich *leaf-mould* that has accumulated under the trees. Here and there a heap of stones has been gathered out of the ploughed soil, and the most cursory glance will show us that they are of several different kinds.

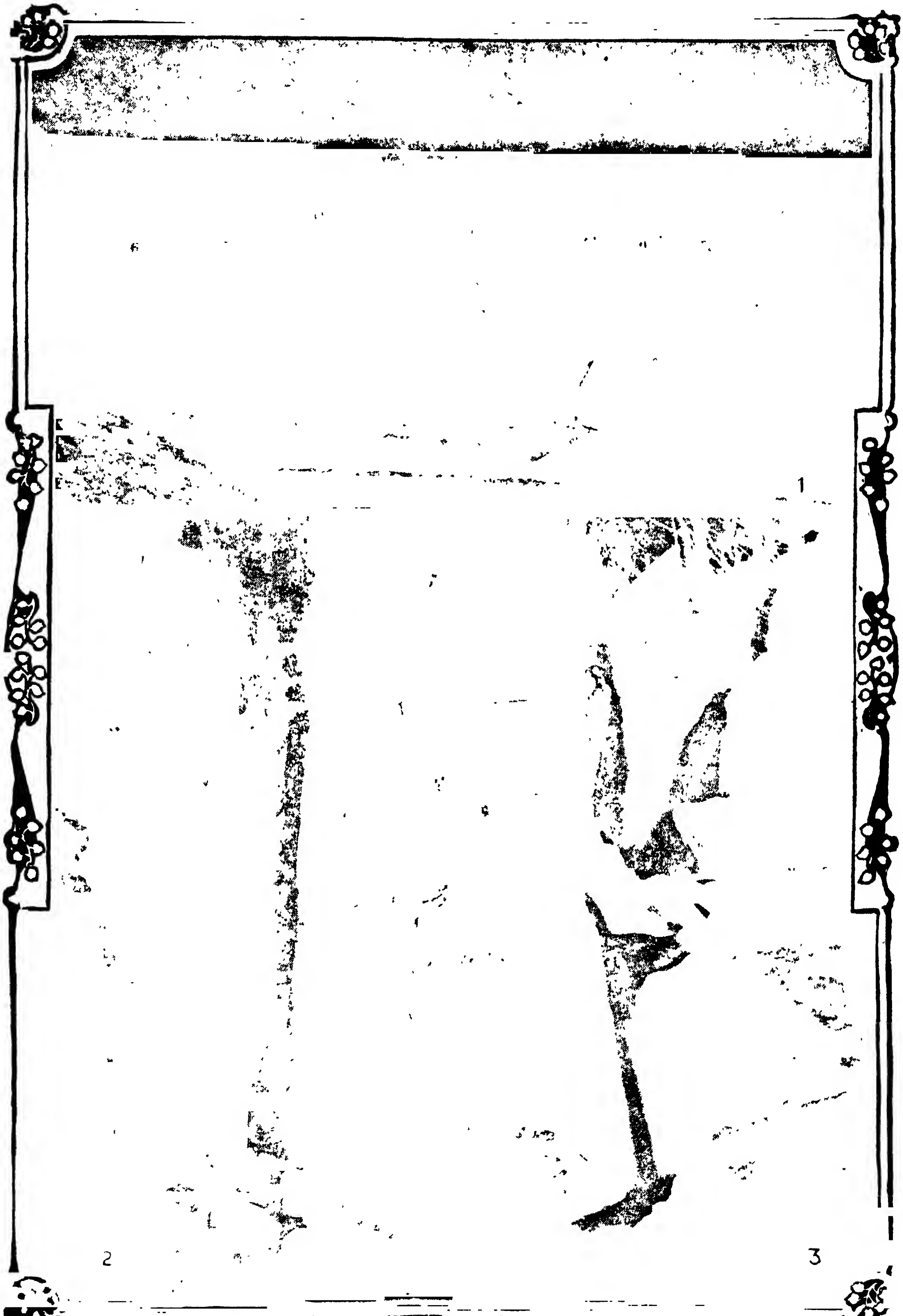
Rivers in Landscape. The path brings us to the side of a little *stream*, and we follow it upwards. It leads us towards the hills which are the usual object of such a ramble, and we note the gradual change in its fashion of running. Down in the open fields it flows along slowly and equably, only a foot or two below the bank on which we are walking. But as we ascend its course it becomes at once smaller and more lively. Here and there the banks rise suddenly, and we cannot fail to notice that the stream is cutting them away, and perhaps we go on to the just conclusion that the whole valley down which it flows was once carved out of the hills by a stronger prehistoric stream. We notice, too, that where the land is cultivated and the soil is soft the stream winds about and makes broad, fantastic curves; but where, nearer the hills, the banks begin to show rocky walls, it runs straight, swift and narrow, in little glens or ravines. It begins to dawn on us that rivers have something to do with the shape of the land. When we go home we take down an atlas, and see that everywhere, on the large scale as on the small, rivers run down from the hills in intricate but ever widening valley-systems to the sea; and it becomes apparent that this is not a mere truism, but a geological fact which helps to explain how the land has been carved into its present shape.

As we continue to ascend our stream, we come to a tumbling *waterfall* [2 and 3]; and if we study it carefully, we shall find that just here the water is coming over a ridge of *solid rock*, much harder than anything which we have seen yet. The running water, which comes down thick with sediment and mud after rain, is constantly wearing away the land; but it cannot act upon the rock nearly so fast as on the softer soil, though it does act upon it, and so the rib of stone has made a kind of wall over which the stream has to plunge. Probably the young geologist has tried on occasion to dig a really deep hole in some garden, and he knows that sooner or later he comes down to this solid rock, which nothing short of dynamite seems able to break up. Yet the running water has made a breach in it: for the centre of the stream is far below the rocky banks that stand up on each side. So two more lessons are added: one, that the soil which covers the earth in most civilised parts is only a skin a few feet thick over the rocky skeleton which underlies it; the other, that even this "eternal rock," as poets call it, is liable to be worn away by running water, apparently the softest and least destructive of things.

How the Land is Moulded. Well, the walk has now brought us up right among the *hills* that were blue on the horizon when we started. The cultivation has come to an end, and we can wander about as we choose. Clearly there must be something to keep the farmer away. It is partly a difference in *soil*, as we can see readily enough when we investigate among the roots of the heather, or pull up some of the short, wiry grass, very different from the luscious pasture down in the valley. Partly it is the change in the *contour* of the land, which is all ups and downs—no place for the harvest cart or the plough. It is the business of geology to tell us what has produced this variation in the outlines of the land. And one of the chief ways in which the question is answered is by the comparison of various places which are in different stages of the same kind of development.

Thus, we go to Beachy Head and watch the waves busily attacking that tremendous coast, eating into the softer parts of the cliffs and leaving the harder places to stand boldly up. If, on the way back to London, we pause on the top of Reigate Hill, and look abroad over the rich valley that stretches away for miles below us [1], we can hardly fail to ask ourselves if the sea did not once wash the foot of the hill on which we stand; and the answer is that it did. We see a range of hills, again, of which all the lower parts are smooth and rounded, whilst the higher summits are fretted into sharp and picturesque crags. We tell ourselves that some vanished agency must have been at work to produce this well-marked difference, and it needs hardly the evidence of the pebbles that we find scratched into long striations on their surface to tell us that all but the high summits were once covered with a sheet of ice, filing down inequalities and leaving a smooth contour.

The Fossil Record. So the *fossil* fishes which are found in the midst of the sandstone blocks quarried high up on the hillside assure us that once the sea rolled over the inland spot on



HOW WATER HAS CARVED THE LAND

1. An old arm of the sea: From Reigate Hill. 2 and 3, Typical waterfalls (2, Scale Force, Crummockwater; 3, Stock Ghyll Force, Ambleside)

which we stand, no less than the discovery of tree-trunks and ferns in the seams of coal [4] assures us that we warm our rooms and drive our engines with the remains of prehistoric forests. We notice some curious little pits on the surface of a sandstone slab which is going to be built into a new house, and they remind us of the day when the material of that slab was a bed of sand by the seashore, just firm enough to receive the marks of a shower of rain which it preserved, under the shelter of the next layer of sand brought in by the waves, through uncounted ages. The footmarks of extinct birds or reptiles tell the same story. The reproduction of the belemnite fossil [5] is interesting as a reminder of the growth of our knowledge in this branch of geological science. Various ages have attributed this fossil to various origins. In pre-Christian civilisation it was held to be a product of a mammal. Later, belemnite fossils were called "fingers from Mount Ida," or "Devil's fingers," with origin undecided. Then the theory was advanced that they were produced by lightning, and was followed by the supposition that they were stalactites. At length investigation proved them to be organic remains, the internal shells of curious gregarious animals that frequented shallow water. A bit of chalk, seen through the microscope, is made up of tiny shells and spicules which once formed part of the minute organisms that basked in the warm waves of a primeval ocean. Everything about us almost may thus be impressed into the service of the geologist, to throw some light upon the strange problems of the building of our world.

The science of geology, then, deals with the *structure and history of the earth*. It must be studied in the field and the quarry, no less than in the lecture-room and the museum, if it is really to tell a vital story. Here it is possible only to give an outline of the chief facts which are known with certainty about the materials of which the earth's crust is made and the natural processes which have built them up into the fair and fertile earth on which we live.

THE MAKING OF THE EARTH

Geology deals chiefly with the *crust* of the earth, because it is the most important part of our planet—the part on which we live. It is also the only part which we really know. Man has done little more than scratch the surface; his deepest borings go down little more than a mile—one four-thousandth part of the distance to the centre. We can, indeed, infer a good deal as to what lies lower down, but we soon come to the intensely heated *interior*, as to the physical condition of which geologists are not yet quite agreed. It is almost solely the crust that we shall study, and chiefly that part of it which lies within a few feet of the surface. First, however, we must take a glance at the history of the earth as a whole. This belongs as much to *astronomy* (the course on which may be consulted for further details) as to geology, but some acquaintance with it is an essential preliminary.

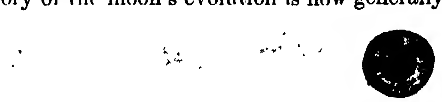
The Earth as a Blaze of Light. The earth was once "a fluid haze of light." The whole *solar system*, in which it is one of the smaller *planets*, was originally a vast *nebula*, or swarm of fiery dust and gas molecules, roughly spherical, and more than 5,000 million miles in diameter. This nebula was all rotating about its centre; it was also cooling, by the radiation of heat into space, and contracting. As it contracted it shed a series of rings at varying distances from the centre, each of which, with one exception, gradually coalesced into a planet revolving round the central portion, which formed the comparatively small star which we call the sun The four outer rings gave birth to the major planets—Neptune, Uranus, Saturn, and Jupiter—which are still in a more or less nebulous condition. The next ring never coalesced, but broke up into a large number of asteroids or minor planets, of which more than 500 have been discovered already. There were still four other rings left behind as the nebula slowly contracted, which formed the four inner and smaller planets—Mars, the Earth, Venus, and Mercury.

Our First Glimpse of Earth. Thus our first distinct glimpse of the earth shows it as a *nebulous star*, still intensely hot, and with no solid nucleus, rotating on its own axis, and at the same time revolving round the sun in a nearly circular orbit. The brilliant researches of Professor G. H. Darwin have illuminated this dawn of terrestrial history in a most curious and interesting fashion. The earth at present revolves on its axis in 24 hours—the artificial measure of time into which we divide the natural unit of the day fixed by the earth's rotational period. But it is steadily losing time. The tides which are diurnally caused by the joint attraction of the sun and moon, sweeping round the earth in the direction opposite to that of its rotation, form a friction-brake precisely analogous to that which is used on the wheels of railway carriages or motor-cars. The retardation thus caused is so small as to be imperceptible in an ordinary lifetime; it amounts only to a lengthening of the day by one second in about a thousand centuries. But in the vast periods of geological time even a tiny change like this accumulates to a serious quantity. And when the earth was still plastic, or even liquid—as it must have been in the process of cooling down from its nebulous state—the tides produced by the sun and moon in its actual substance must have operated as a far more powerful brake.

Calculating this secular retardation backwards, Professor Darwin showed that there must have been a time when the day was only two or three hours in length. The effect of tidal friction also operates on the *moon*, since, by Newton's Second Law of Motion, action and reaction are equal and opposite. The moon is constantly travelling away from the earth, and at the same time revolving more slowly. Working this problem also backwards, Professor Darwin was able to show that there must have been a time when the earth was rotating in a period of between two and three hours, and the moon was revolving round it at the same period, at a distance almost inappreciable.

The Origin of the Moon. Another step in this luminous research was to show that when the earth was a liquid spheroid, rotating rapidly about its axis, it must have been in a state of dangerously *unstable equilibrium.* We do not know the exact speed with which it began to rotate after the nebular ring had coalesced, but we do know that at first, under the influence of solar gravitation, that speed must have tended to increase. Thus the liquid globe of the earth was exposed to two contending forces — that of gravity, which held it together, and that of the so-called centrifugal force, which tended to make it break up, as a grindstone or a fly-wheel bursts when spun too fast. It can be shown that when the period of the earth's rotation had decreased to about two hours and twenty minutes, these two forces were exactly balanced. The least increase in speed would overcome the force of gravity, which of course remained constant, and something must give way.

"The Moon Flung Off From the Earth." It cannot be a mere coincidence that the calculation of the moon's motion, when it was all but in contact with the earth, shows that it must have made a complete revolution in something between two and two and a half hours. The conclusion is irresistible. Originally the moon formed an integral portion of the earth. But as the speed of the earth's rotation increased under the gravitational pull of the sun, it crept up to the critical velocity at which the earth could no longer hold together. There was a vast cataclysm, beyond anything which we can imagine, and the moon was flung off from the spinning earth—possibly in the form at first of a meteoric ring, which eventually condensed into our satellite. As soon as the moon had an independent existence, it set up vast tides in its parent earth, which acted as a powerful brake. The earth's rotation began to slow down again, and the moon began to travel outwards in a widening spiral. This beautiful theory of the moon's evolution is now generally

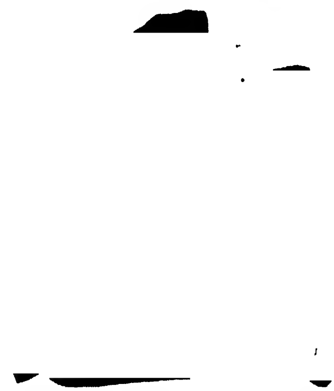


5. BELEMNITE FOSSIL FROM OXFORD CLAY

accepted. Thus we can read the history of the first, and still the greatest, geological cataclysm of which there remains any record.

The Earth and its Envelopes. The earth, as we know it, is an *oblate spheroid* [6] a globe, that is, which is slightly flattened at its poles, which are the ends of the axis about which it revolves. Its equatorial diameter is about 7,926·59 miles, and its polar diameter about 7,901·47 miles. The cause of this departure from the perfectly spherical form—which would have been assumed by the earth if its materials had coalesced under the sole influence of gravity and cohesion—is the earth's rotation combined with the solar tide. Calculation shows that the present shape of the earth is that which would have been assumed by a liquid globe rotating at its present speed, whence we conclude that the earth solidified at a time when its rotational period was practically the same as it is to-day.

The earth consists of shells, like an onion. It is a globe covered by a solid crust—the *lithosphere*—which is surrounded by an envelope


4. FOSSILS OF FERNS IN COAL SEAM

of air—the *atmosphere*—and in part by an envelope of water—the *hydrosphere.* It is the lithosphere, and especially the crust by which it is bounded, with which geology is mainly concerned. The outer envelopes are chiefly of interest from the effect which they have on the surface of the crust.

Atmosphere and Water. The atmosphere, or outer envelope of the earth, consists chiefly of the air we breathe, a mechanical mixture of the gases oxygen and nitrogen, in the proportions by volume of about 1 to 4—exactly 20·6 O to 79·4 N—with a small, varying amount of carbon dioxide and water vapour, and traces of rare gases like argon and helium. It extends perceptibly to a height of at least 150 miles, though more than half of it is compressed by gravity to within three miles of the surface. It is equal in weight to an envelope of water covering the whole earth to a depth of 34 ft., and exerts a pressure on all substances at sea-level of rather less than 15 lb. to the square inch (one atmosphere). Its geological effects are very considerable, as the rocks of the lithosphere are superficially modified by wind—laden with dust—rain, hail and snow.

The *hydrosphere,* or surface water of the earth, also plays a great part in the work of geological change. This water is sufficient, if the surface were a dead level, to cover the whole earth to a depth of nearly two miles. But the various forces which have been at work in the course of the last hundred million years or so have modified the earth's surface so that it presents considerable inequalities of level, ranging from five miles above the mean level in the highest Himalayan summits to six miles below it in the deepest abysses of the ocean. Consequently, the water of the hydrosphere has chiefly collected itself into the seas which occupy the depressed

portions of the surface, and which cover nearly three-fourths of the whole area of the earth—about 145,000,000 square miles. A considerable part of the water is always suspended as *vapour* in the atmosphere, and a complete system of circulation is set up under the solar influence. [See the Course on GEOGRAPHY.] The water evaporates from the seas, falls as rain on the land, and is returned to the sea by the rivers which it thus forms. It is one of the most effective agents in the geological operations which are constantly altering the surface of the earth.

The Solid Earth. The great bulk of the earth consists of the *lithosphere*, or solid globe of rocks, with which geology properly deals. It is on the part of this lithosphere, composing a little more than a quarter of the earth's whole area—55,000,000 square miles—which rises above the seas and is called land, that mankind lives. Practically the whole of its surface is exposed to the study of the geologist, who is also acquainted with its interior structure, as displayed by mines and bore-holes, to the depth of something over a mile. It is his business to form inferences as to the condition of the parts which he cannot directly explore. He has also to tell us why the land is diversified so much, by plain and table-land, mountain-range and valley-system; why the rivers flow through it, and what dominant force has traced their courses; why one kind of soil is better suited than another to the purposes of agriculture; and how the miner can best prospect for the shafts with which he hopes to tap the mineral resources of the earth's interior. Only a long and thorough course of study can enable him to do all this; but the principles on which he depends will be outlined in the following chapters.

Astronomy has already taught us that the earth was once so hot as to be a mere nebula, composed either of fiery gases or of glowing particles of matter such as we now call meteorites. We know, by common experience, that its surface is now cool and hard, and mostly composed of solid rocks, with a mantle of soil varying from one or two to hundreds of feet in thickness. How has this great change been brought about?

Influence of the Earth's Motion. We know that three different agencies have been at work on the original nebula. It was originally in motion, rotating around its own axis, and this motion has been preserved and handed on to the earth. It was intensely hot, and has been losing heat ever since. And it was made up of some sixty or seventy different substances—the so-called elements of the chemist—which have since entered into numerous kinds of combination with one another.

First let us consider the influence of the earth's *motion*. Everyone knows that a rotating body tends to take a circular or spherical form. If you whirl a skipping-rope round your head, its handle moves in a circle; if you spin a chain-bracelet, it stiffens into a circle as it moves; a lump of snow rolled along the ground takes a roughly spherical shape. Further, a drop of liquid always takes a spherical form, even when it is not in motion, under the influence of other forces. [See PHYSICS.] Thus the nebulous mass which was to give origin to the earth speedily assumed the globular shape which characterises every star or planet or satellite that we have yet discovered. But, as we have seen, it was also under the influence of the sun's attraction, and this combined with its rotation to make it bulge a little at the equator—though, for practical purposes, we may consider it as a perfect sphere. If we represented the earth by a globe five feet in diameter, the flattening at the pole would be less than one-tenth of an inch.

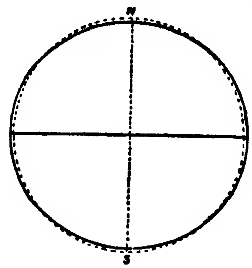
The Earth Cooling. Secondly, the nebulous earth has constantly been losing *heat* by radiation out into space. All bodies, with some negligible exceptions, contract as they cool. A considerable volume of steam liquefies into a few drops of water, which change into solid ice with very slight alteration in bulk—this, by the way, is one of the exceptions, since water expands in freezing. The great mass of nebulous matter which once formed a sphere 5,000 million miles in diameter, has solidified into the sun and planets, which all put together would form a sphere of only about one five-thousandth of that diameter. Thus the nebulous earth steadily contracted as it lost heat, until finally it began to change from glowing gas into a very hot liquid—a globe of molten rock—from which, as we have seen, the moon was shot off under the influence of the centrifugal force.

The exact steps of this *liquefying process* are still in doubt. We can never hope to trace this far-off part of the earth's history with any great accuracy; it is so much a question of inference and hypothesis. Some hold that the liquefying process began at the centre of the nebulous mass; for though the heat may have been greatest there, so was the pressure, amounting perhaps to 3,000,000 atmospheres, or 20,000 tons to the square inch—and we know that the melting point of nearly all substances rises in proportion to the pressure exerted on them. Others assert that it began at the outside, where cooling was fastest. What is certain is that it did begin somewhere, and continued until the whole vast nebulous bulk had shrunk into what we may for brevity call a liquid or plastic globe some 8,000 miles in diameter.

The Solid Crust. Meanwhile, *chemical changes* have been going forward. At the high temperature of the original nebula it is probable that all the elements existed by themselves, being too hot to enter into combination. [See CHEMISTRY.] But as they cooled they began to form compounds; the iron and the oxygen rushed together, producing some oxide of iron; hydrogen and oxygen gave birth to water-vapour, silicon and oxygen produced quartz, and so on. At this stage the history of the earth belongs rather to chemistry (*q.v.*) than to geology.

The geological story really begins with the formation of the *solid crust* on the surface of

this liquid globe. As the secular cooling went on, the outer parts of the liquid mass must have begun to harden and solidify, just as the lava from a volcano or the slag from a blast-furnace hardens when exposed to air. At first, no doubt, the hardened portions sank into the fiery liquid, and were dissolved again, but in time they began to become thicker and larger, and to adhere together, until at last the



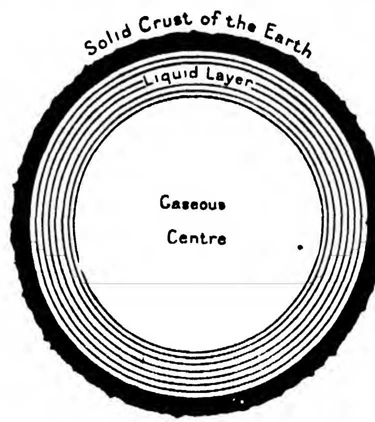
6. AN OBLATE SPHEROID ILLUSTRATING FLATTENING OF THE EARTH AT THE POLES

whole globe was covered with a skin of solid, though still intensely heated, rock. The atmosphere meanwhile shrouded this globe, and began to check the rate at which heat was lost; it contained not only the air which we breathe to-day, but all the water of the oceans and rivers in the shape of superheated steam, as well as vast quantities of carbon dioxide, much of which is now fixed in our coal-measures.

Heat of the Earth Within. An important evidence of the formation of this solid crust is to be found in the well-known fact that the earth is still *hotter within* than it is on the surface. The phenomena of volcanoes, geysers, and hot springs bear witness to the existence of some internal reservoir of heat. That this is not merely local, but universally distributed, is shown by the fact that wherever we bore into the earth's crust we find the temperature steadily increasing as we go down. On the average, the increase is 1° C. for every 90 ft. of descent. The actual rate varies widely according to the local conditions, but that is about the mean of numerous observations. If this rate were kept up, the temperature at the centre of the earth would be over 200,000° C. Probably the rate of increase does not remain so great; it must be remembered that we can follow it for only six or seven thousand feet. But there is no doubt that the interior of the earth is exceedingly hot. At a depth of 100 miles the temperature would be 5,700° above that of the surface, and no known substance would in the ordinary course remain solid. Thus the earlier view of the earth held it to consist of a solid crust, 50 to 100 miles thick, floating on a molten globe, which served as the common reservoir for volcanoes.

Condition of Earth's Interior. But this view has been seriously modified by the progress of knowledge. Astronomers have shown that, if the earth's interior were really fluid, the sun and moon would cause vast tides in it which would seriously perturb the motion of our satellite. Nothing of the kind takes place, and it has been calculated with entire certainty that the earth, as a whole, must be far more rigid than if it were a globe of solid steel. The earlier geologists omitted to take account of the immense pressures which the weight of the superincumbent strata exerts upon the materials of the earth's interior, and which greatly raise the melting-point of the ordinary rocks. [See Course on PHYSICS.] Thus, the modern view is that the interior of the earth is practically solid all through, in spite of the immense temperature which must prevail in it. The best theory is that of Professor Arrhenius, who has put forward the view that the earth is a vast bubble, consisting of a solid crust [7], perhaps 30 or 40 miles thick, resting on a liquid magma of 60 to 100 miles, which shades off into a globe of gas.

But this gas is very different in physical properties from any which we know in our laboratories. That it is gas we argue, because the temperature at this depth must be higher than the critical temperature of any known substance —*i.e.*, the temperature at which a substance can remain solid or liquid under any pressure. [See PHYSICS.] But it is gas under a pressure so vast that its density is two or three times greater than that of any known rock, and its rigidity and incompressibility



7. SECTION THROUGH THE EARTH

are greater than those of steel. Probably at least half of this gas consists of iron and other metals. It is almost impossible to realise this condition of matter, but a number of arguments—such as those based on the speed with which seismic waves are transmitted through the substance of the earth, and on some anomalies of volcanic action, as well as that derived from what we know of the behaviour of substances at high temperatures and under great pressure—make it equally difficult to get away from its necessity.

The Earth as it is. The earth, then, which geology has to study, consists of *a series of shells of matter* in different states [7]. The *central core* is a globe of about 7,600 miles in diameter, which

is composed of iron and other elements, probably not forming compounds, in the gaseous state, but exposed to such tremendous pressure that it behaves as a solid and extremely rigid body. Outside this core is a *shell of liquid matter* which consists of all the rocks which we know at the surface in a state of fusion, perhaps 100 miles in thickness. Upon this magma floats the *solid crust*, 30 or 40 miles thick, which is composed of the various rocks which we have now to study, breaking down at the surface into soil. Three-fourths of the surface of this crust are covered by the *water of the oceans*, the hydrosphere, the rest being dry land. Outside all comes the *atmospheric mantle*, chiefly composed of air, which supports life, acts as a blanket to keep the earth warm and a shield against the blows of meteorites, and extends to a perceptible height of about 150 miles.

The Materials of the Earth's Crust. Before we can proceed to consider the later history of the earth, and to ask how the hot, bare rocks, of which the surface was originally composed, have given birth to the habitable earth on which we live, with its varieties of soil and contour, we must study the materials of which they are composed. Within our limits it is possible to take only a brief survey of the more important of these.

Minerals and Rocks. We shall first consider the *minerals*, which are the chief constituents of the earth's crust, and shall then pass on to inquire how, and under what conditions, they have given birth to the *rocks* which build up the earth's surface. Two definitions may be given here, but it must be noted that they do not bear the weight of definitions in chemistry and physics.

A *mineral* is a naturally-formed non-living substance which is composed of one or more chemical substances, and has certain definite physical properties by which it may always be recognised.

A *rock* is "a mass of matter composed of one or more simple minerals, having usually a variable chemical composition, without necessarily symmetrical external form, and ranging in cohesion from mere loose débris up to the most compact stone." (Geikie).

Examples of familiar minerals are diamond, iron pyrites, quartz or rock-crystal, calcite or Iceland spar, common salt, mica. All constituents of the earth's crust are known as rocks, in the geological sense, when they occur in mass. Mud, sand, and loam are rocks, as are granite, lava, sandstone, limestone and coal.

We shall begin with an account of the chief *rock-forming* minerals, and the elements which compose them.

Chief Elements which form Minerals. The earth's crust is composed of some sixty or seventy *elements*, or bodies, which cannot as yet be analysed into simpler substances. [See CHEMISTRY.] Most of these are found in the sun and other stars, as is obvious from the nebular theory, which presupposes a common origin for bodies which form part of our system, or, indeed, of our universe. The larger number of these elements, however, play so small a part in the constitution of the earth that they may be neglected by the elementary geologist. The following list includes the elements of which 99 per cent. of the earth's crust, as known to us, is composed, with their relative proportions, as indicated by Clarke's laborious analyses of a very large number of typical rocks:

Element.	*Chemical Symbol.*	*Percentage of earth's crust which it forms.*
Oxygen	O	47·02
Silicon	Si	28·06
Aluminium	Al	8·16
Iron	Fe	4·64
Calcium	Ca	3·50
Magnesium	Mg	2·62
Sodium	Na	2·63
Potassium	K	2·32
Hydrogen	H	0·17
Carbon	C	0·12
These ten elements form of the earth's solid crust.		99·24%

Hydrogen, of course, is of importance as one of the constituents of water, which enters largely into the composition of many rocks. *Nitrogen* (N), which forms no appreciable part of the crust, should be added to the list on account of its presence in the air. For an account of the properties of these and other elements, the reader is referred to the course on CHEMISTRY. The various minerals which we have to study in geology are compounds of these elements. About 800 of these are known, and distinguishable wherever they occur by their permanent characteristics. We need only make acquaintance here, however, with a comparatively small selection of the more common minerals. Some minerals, such as coal and the ores of the various metals which enter so largely into our industries, have a practical importance which is out of all proportion to their place in the general geological scheme, and the course on MINING will deal with many which we must here be content merely to mention.

Continued

A RAPID SURVEY OF THE WORLD

The World Near the Poles. The Tundra. Cool and Warm Lands. The Deserts. Vegetation. Government and Races of the World

Continued from page 558

By Dr. A. J. HERBERTSON and F. D. HERBERTSON, B.A.

The Shaping of the Coast. The coast, or margin of sea and land, is an area rapidly wearing away under the ceaseless influence of the waves and of the sand and shingle they are perpetually hurling to and fro. Coasts may be either flat or high, composed either of hard or soft rock, and either drowned or raised. A drowned coast is one where the land has sunk or the sea has risen, so that the low grounds and valleys are flooded. A raised coast is one where the land has risen or the sea has retired, so that what was formerly the sea bottom is exposed.

A flat coast is usually sandy, often bordered by sandhills and lagoons. It may be carved into cliffs, as in the clay cliffs of Norfolk. A raised coast is usually flat from the long-continued action of the waves during the period when it was submerged. Flat coasts have no good harbours.

A submerged, or drowned, coast differs according to the nature of the submerged region. If this was hilly or mountainous, with valleys running parallel to the shore, the coast will be ironbound and harbourless unless the sea-level has risen sufficiently to give access to the valleys behind the first range of heights. If this happens T-shaped gulfs are formed. Where the valleys open at right angles to the sea they become bays, usually with excellent harbours. The hills between the valleys rise as peninsulas, or islands. If the land was flat before drowning took place a flat coast is the result.

Glaciated valleys, which have irregular floors and steep sides, form fiords when submerged, of the type seen in Norway and in the west coast of Scotland.

Where the land is composed of soft rocks a more uniform coast-line results than where it is composed of harder rocks, or of hard and soft rocks mixed. The waves in eating out the softer rocks often form magnificent sea caves, natural arches, and pinnacles.

THE LIVING WORLD

We have concluded our survey of the various forces which are continually at work on our planet. Let us briefly summarise the results. The rotation and revolution of the earth, together with the inclination of the axis, tend to equalise the distribution of temperature over the whole surface of the globe. This is further promoted by the great systems of winds and ocean currents, which cause an interchange between the hot and cold air and the hot and cold surface waters of differently heated parts of the earth's surface. In the cycle of changes which raises a drop of moisture from the ocean, carries it through the vast whirls of the atmospheric circulation, to fall at last as rain, and be ultimately restored to the ocean through the agency of rivers, we have a beautiful provision of Nature for furnishing that constant supply of moisture without which plant life, and with it animal and human life, would vanish from the earth. Our study of the rainfall system showed how this supply of moisture is distributed in the form of rain as uniformly as may be over the globe. Finally, we saw how a whole set of forces, heat, cold, and water in the form of rain and river, are working on the irregular outlines of the land surface, wearing down the heights, filling up the hollows, and tending to bring about a surface of uniform elevation over which movement in all directions would be easy. While we cannot say that all these forces are contrived to fit the earth to become the home of man, there is at least no doubt that such is their outcome.

The Far North. We have distinguished six climatic regions—the polar regions, the cool temperate lands, the warm temperate lands, the hot deserts, the hot inter-tropical lands with a summer rainy season and a winter dry season, and the equatorial lands with constant rains. Well-marked vegetation zones correspond to these.

For a varying distance round the Poles the land is so completely buried beneath ice and snow that we do not know with certainty whether it consists of land or sea. Beyond this comes the *tundra*, a poor moorland, frozen always to the depth of many feet, and covered with snow for most of the year. It has a brief summer, when the snow melts and the hard ground thaws on the surface for a few inches. A dwarf vegetation struggles into life, consisting of tiny berry-bearing bushes—cranberries and the like—and of "lichens and mosses of every conceivable colour, from the cream-coloured reindeer moss to the scarlet-cupped trumpet moss, interspersed with brilliant Alpine flowers." The only tree, if such it may be called, is the dwarf birch, dwindled to a bush a foot or two high. Towards the margin of the tundra it begins to increase in size, and dwarf pines and firs appear. The trees increase in number and size, and the tundra passes gradually into poor, thin forest.

Forests of Cool Temperate Lands. On the margin of the tundra farthest from the Poles we have a scanty forest of stunted birches and firs, gradually becoming denser till they form vast forests of noble trees. The whole of the cool temperate lands in both the Old and the New Worlds were once entirely covered with forest, consisting in the north of trees with needle-shaped evergreen leaves—the coniferous pines

and firs—and in lower latitudes of trees which lose their leaves in winter—*deciduous* trees—such as the oak, elm, beech, etc. These forests still cover hundreds of thousands of square miles in North America and Asia, but they have been cleared in Europe, except in the north and east and on the highlands of the centre. In the Southern Hemisphere they are found in the forests of Chile and Southern New Zealand.

Forests of Warm Temperate Lands. The warm temperate lands lie in less rainy latitudes than the cool temperate lands, and, except on the margins, are too dry for forests. New species of trees, better suited to warmer climates and drier, appear. In Europe the Spanish chestnut is a link between the deciduous forests of Central Europe and the evergreen forests of Southern Europe and Northern Africa, in which the commonest trees are evergreen oaks, including the cork oak, and species of pine never seen in the colder North. In the Southern Hemisphere warm temperate forests are found in the southern part of Brazil, in South America, in Natal, South Africa, and in New South Wales and Victoria in Australia. In the Australian forests the chief trees are acacias, or wattles, and different species of eucalyptus or gum-trees, with their leaves hung sideways to reduce evaporation from the surface. Over most of the temperate region however, the rainfall is so scanty that forests are replaced by steppes or grasslands.

The steppes are found towards the interior of the continents in the warm temperate belt. The climate is extreme and the rainfall scanty. After the severe winter the ground thaws and becomes very moist, while the sun is powerful, so that vegetation comes on with a rush. Plants which quickly come to maturity do best in such conditions, as may be easily imagined by those who have watched the unequal race between perennial plants and quick-growing annuals in any garden. Trees require many seasons for growth, while grasses germinate, bloom, and die in a few weeks. On the steppes the latter shoot up with great rapidity, and with a few weeks of hot sun and thunder-showers they grow to the height of a man. Trees have no chance against them. Little saplings a few inches high struggle for life every spring, but they are quickly choked in the sea of grass, and cut off from light and air. Bulbous plants, which root easily in the loose soil and come into bloom before the grass is too high, also do well. They form a beautiful feature of the steppes in spring.

An Ocean of Green and Gold. "Boundless tracts," writes a traveller, "are resplendent with tulips—yellow, dark red, white, white-and-red. Immediately after the tulips come the lilies. They completely dominate wide stretches. Usually each species is by itself, but here and there blue lilies and yellow are gaily intermingled." Another writer, describing the steppes later in the year, says: "The steppe was nothing less than a green-gold ocean, whose surface seemed besprinkled with millions of different coloured flowers. Here, through the tall, thin grasses, were to be seen purple, blue, and violet cornflowers; there the pyramidal top of a yellow vetch shot up suddenly; there the umbrella-shaped heads of clover shone like so many white spots; some ears of wheat, brought Heaven knows whence, were slowly ripening among the grass." Early maturity is followed by early decay By July the steppe is parched and brown, and the animals are dying from thirst in a treeless land, where shade is unknown. Autumn finds a barren, desolate land.

In the Southern Hemisphere steppe lands are found in Patagonia, in South America. The grasslands of the karoo and veld in South Africa are a transition type to the savanas described below.

Where the rainfall diminishes, as it does towards the Equator and away from the sea, the vegetation of the steppes becomes poorer, and they pass gradually into desert or semi-desert.

The Hot Deserts. The hot deserts lie in the trade-wind area, or in their lee, as we saw in studying climate. They are, like all the vegetation zones, most extensive in the Northern Hemisphere, and particularly in the Old World, where the land is broader in the latitudes of the trade winds than in the New World, or in the Southern Hemisphere. The Desert of Sahara, which is continued by the deserts of Arabia, Persia, and Central Asia, forms an almost continuous belt, the most extensive desert area in the world. In the New World we find the deserts of the western United States in the Northern Hemisphere, and the deserts of Peru and Chile in the Southern. The other deserts of the Southern Hemisphere are the Kalahari desert of South Africa and the desert in the interior of Australia, the second largest in the world.

The surface of a desert may be either flat or hilly, and composed either of sand, stones, or white alkaline deposits. The character common to all is the more or less complete absence of vegetation, due to the lack of rain, and not necessarily to any natural infertility of the soil. What vegetation exists is of hard, prickly plants, whose leaves are adapted either by their shiny, leathery surface or by their small spinelike character to lose as little moisture as possible by evaporation from their surface. [The mode in which plants breathe and perspire is described in NATURAL HISTORY.] Aloes and cactuses are the characteristic plants of the American deserts, gum acacias and tamarisks of the Sahara, the wait-a-bit thorn and other prickly plants of the South African desert, and the dreaded spinifex and mulga of the Australian deserts.

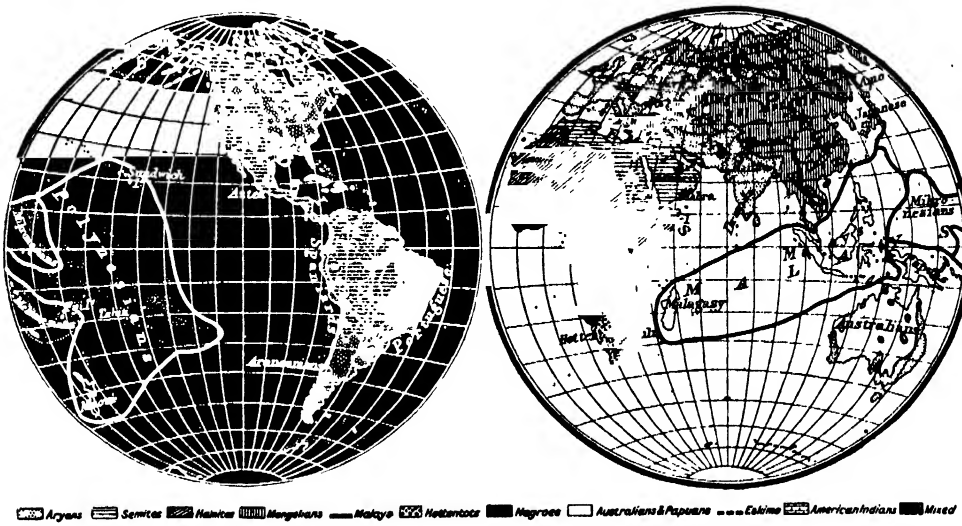
How Water is Stored in the Deserts. Many desert plants possess the power of storing up water, generally in their roots. The natives of Australia are skilful in obtaining water from the long roots of the mallee, a desert eucalyptus. A plant of the North American desert is known by the expressive name of the "well of the desert." By cutting out its centre a bowl is formed which quickly fills with excellent water. In the Kalahari desert the water-root has saved hundreds of dying from thirst. The ground round its large oval bulbs is generally so baked

that it has to be hacked away with a knife. Its bulbs are eagerly sought by both man and the lower animals.

The desert is infertile because it is too dry for vegetation. Rain falls at rare intervals, and then usually in torrents, filling the dry river-beds for a few hours with a raging torrent. In various parts of the desert springs occur, and then fertile spots, or oases, break the monotony of the scene. The waters of the springs are carried by means of canals to every part of the oasis, the size of which depends on the quantity of water available for this purpose. This mode of supplying cultivated lands in the dry regions with water from a spring or river is called irrigation. In the oases of the African and other Old World deserts the date palm is the chief product; but other fruits, as well as cereals and cotton, are cultivated. In many of the drier regions of the world use is made of the great stores of underground water. Very deep wells are sunk till these are reached, after which irrigation becomes possible. Thousands of such wells have been sunk in the drier parts of Australia and the United States.

Vegetation of Hot Lands with a Summer Rainy Season. Such hot lands are found on both sides of the wet equatorial belt, extending as far as latitude 35° or 40°, according to the height, exposure, and configuration of the country. The cause of the summer rainy season has already been explained. This savana region, as it is called, consists of grasslands with clumps of trees which do not form woods or forests. The trees are of kinds unknown farther north. They have massive trunks, with thick bark, and many spread out their branches in umbrella fashion. Many of them store up water against the dry season, which, though winter, is still hot. Lands of this type, with fine trees dotting a grassy landscape, are often called parklands, from their resemblance to the scenery of an English park. They are found in the northern part of South America, where they form the llanos of Venezuela and Guiana, and south of the Equator in the campos of Brazil and in the pampas of Argentina. They occur in Africa, north and south of the Congo forests. In Australia the Darling Downs, and other grasslands of the north, are in the savana region, which is restricted in area by the widespread drought of that continent. Parts of India, South-East Asia, and the East Indies, usually at some elevation, are also savana lands. Savana lands due to elevation are found on mountains in the equatorial belt at the height of a few hundred feet.

The Equatorial Forest. On each side of the Equator are regions of constant heat and moisture, forming a sort of natural hothouse. Nowhere else does vegetation develop in such luxuriance. Trees known in other latitudes as dwarfs become giants, and new and colossal species appear. Dense forests cover many thousands of square miles in the basin of the Amazon in South America, in the Congo basin of Africa, and in South-East Asia and the adjacent islands. Many of the Pacific islands are also densely forested.



51. THE RACES OF THE WORLD, AND THEIR HOMES

Perhaps the best description of the equatorial forest is by Stanley, in his description of the forests of the Congo. "Imagine a space," he writes, "four times the size of England, Scotland, and Wales crowded with colossal trees 200 ft. in height, with their thick, glossy foliage so interlaced that the hot, glaring sun of the tropics is quite shut out. Each tree is seemingly lashed to every other by endless lengths of numberless cables ranging from tender, thread-like creepers to others of the thickness of the old hempen hawsers of a line-of-battle ship. Underneath the thick, impervious shade is the impenetrable undergrowth, so close that you could

travel easier above the top of it. Imagine the forks of each tree crowded with little conservatories of orchids and ferns, and their great horizontal limbs burdened with grey-green lichens with leaves as large as prize cabbages, and with drooping epiphytes, or air plants, as well as hosts of tendrils swinging ceaselessly about, and here and there great swaying walls and nodding towers of vines, round the flowers

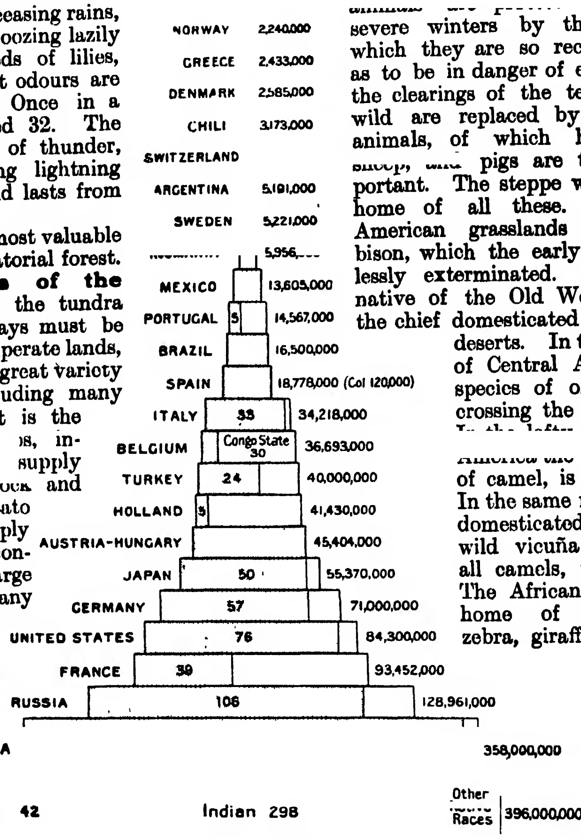
palm along the shores, the bread fruit, and roots such as the yam are grown.

Animals. The wild animals of the world disappear rapidly wherever man penetrates, and domesticated animals are introduced by him wherever he makes permanent settlement. In the Polar seas the seal and walrus are hunted for their furs. In the tundra the reindeer has been domesticated. Its hoof is specially fitted for moving over the boggy ground in summer, in winter beneath.

bank, and fed by never-ceasing rains, coursing impetuously or oozing lazily from under floating beds of lilies, while the sickening-sweet odours are almost overpowering. Once in a 10-mile march we crossed 32. The rain comes after bursts of thunder, with displays of dazzling lightning and raging tempests, and lasts from four to fifteen hours."

Rubber is among the most valuable wild products of the equatorial forest.

Cultivated Plants of the Various Zones. In the tundra agriculture is and always must be impossible. In the temperate lands, warm and cool, we get a great variety of useful products, including many cereals, of which wheat is the ... is, in- supply winter fodder for live-stock and those which, like the potato and sugar beet, supply articles for human consumption; a very large range of fruits, and many industrial plants. The range of products is, on the whole, greater in the warmer lands, as the plants of cooler latitudes can be grown at suitable elevations. In the warm temperate lands maize and millet become the most important cereals. Rice and cotton, which are sub-tropical plants—that is, belong to latitudes near the tropics, are grown in the hottest parts. The steppes are grazing lands, but where not too dry are very suitable for the cultivation of cereals. In the savanas the banana becomes an important article of food, and coffee, sugar, ... At elevations most temperate products do well. In the equatorial forest belt there is little agriculture, except of a primitive type in the clearings. In the forests of Eastern Asia the sago palm is a staple food. In the Pacific islands the coco-nut



52. POPULATION OF THE CHIEF STATES OF THE WORLD

The population of the Home Country is shown by the shaded area. The figures inside the rectangles give population in millions

severe winters by thick furs, for which they are so recklessly hunted as to be in danger of extinction. In the clearings of the temperate lands wild are replaced by domesticated animals, of which horses, cattle, sheep, and pigs are the most important. The steppe was the original home of all these. The North American grasslands teemed with bison, which the early pioneers recklessly exterminated. The camel, a native of the Old World steppes, is the chief domesticated animal of the deserts. In the higher parts of Central Asia the yak, a species of ox, is used for crossing the highest passes. In the lofty Andes of South ... of camel, is similarly used. In the same region the semi-domesticated alpaca, and the wild vicuña and guanaco, all camels, may be noted. The African savana is the home of the elephant, zebra, giraffe, lion, leopard, rhinoceros, and innumerable antelopes, while the hippopotamus haunts the rivers. In the tropical forests of Asia the tiger lurks, but large animals are not numerous in the equatorial forest anywhere. The animals of South America differ considerably from those of Africa. The largest beast of prey is the puma, or South American lion. Australia, when discovered, was very poor in animals. The most remarkable was the kangaroo. Of animals introduced by Europeans the rabbit has bred till it is a dangerous pest.

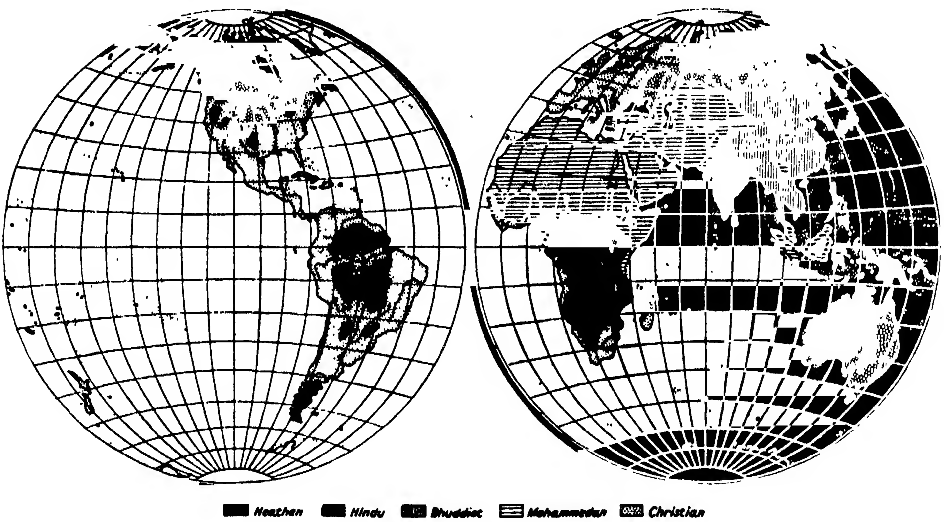
A word must be said of creatures hostile to man. The mosquito is supposed to be the means by which malaria is spread, and if so, many parts of the world will continue dangerous till it is exterminated. The tsetse fly of Africa

prevents the keeping of animals where it is found, and unfits large areas for settlement.

Man. Man is the most widely distributed of all animals, being found from the polar seas to the equator. This he owes to the possession of superior intelligence, which enables him to suit himself to his surroundings. It is often said that man conquers Nature—a difficult task. It is truer to say that he co-operates with Nature, adapting himself to her imperious laws. He becomes hunter, fisher, keeper of animals, farmer, as the character of his home suggests, and thus he can live almost anywhere. His great discoveries have been the making of fire and the practice of agriculture.

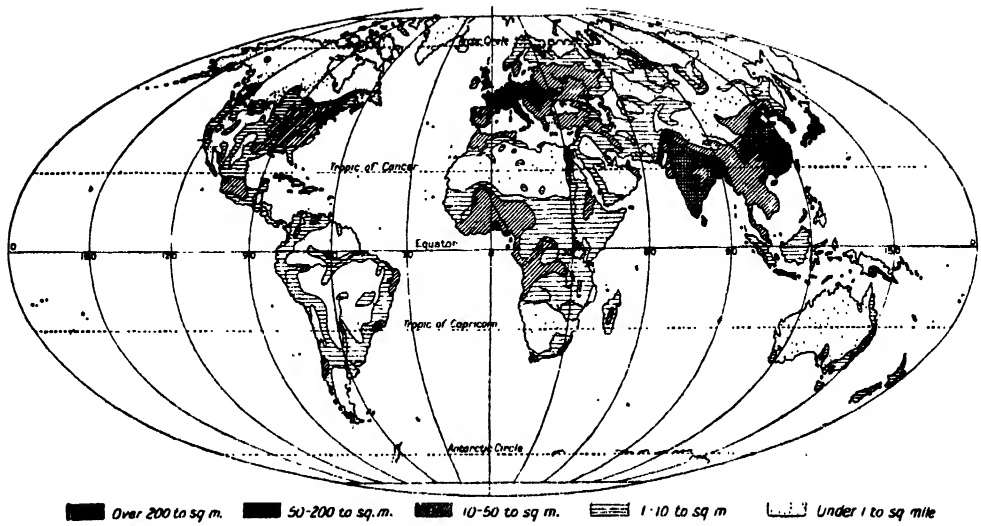
Races. There is no general agreement as to the number of races in the world [**51**], and experts cannot agree whether all have developed from one, nor what was the place of origin. The white, or Caucasian race, many branches of which are very dark in colour, occupies most of Europe, and a great part of Asia. Its members have also colonised all the New World, South Africa, and Australia, and are now trying to settle in the tropics. The yellow, or Mongolian race, occupies Eastern Asia. In South-east Asia is the Malay, or brown race. A great part of Africa is occupied by the black, or negro race. There is a large negro population in the southern parts of North America and in Brazil, descended from slaves imported from Africa. Peoples of negro blood are also found in Southern Asia, and the Malay Archipelago, and in the islands of the Pacific south of the equator, and west of 180°. The inhabitants of the other Pacific islands are probably of very mixed blood. The aboriginal inhabitants of the New World, or Indians, are sometimes classed as belonging to the Red Race, and are probably descended from the Yellow races. Certain peoples, like the Pigmies of the Congo forest and the Bushmen of South Africa, seem to belong to a primitive dwarf race, perhaps the earliest type of man [**52 and 54**]. The different races regard each other with dislike. The white race, in particular, declines to intermarry with the others, though irregular unions have produced a fairly large half-caste population. It is doubtful if this attitude can long be maintained. Japan, now a first-class Power, will conceivably claim to intermarry with European reigning houses, and it is difficult to see how the privilege could be refused. This would introduce a new principle into the world, and might naturally lead to the formation of a composite race combining the best qualities of each.

Religion. In Europe, and countries colonised from Europe, the prevailing religion is Christianity in one or other of its great forms—Roman Catholicism, Greek Catholicism, and Protestantism, the last-named including many sects [**53**]. In Turkey the religion is Mohammedanism, a creed which finds a following from the Atlantic to the Pacific, but is especially powerful in the desert and semi-desert lands of Africa and Asia. Only Buddhism, largely professed in Central and Eastern Asia, can be compared with these two in universality. Brahminism, a philosophical Nature worship, has millions of adherents in India. Confucianism in China, and Shintoism in Japan, are both primarily ethical. The African savana and forest lands and the islands of the Pacific produce many varieties of degrading and cruel religious beliefs.



53. THE RELIGIONS OF THE WORLD

Government. In early stages of society there is probably no choice between anarchy and despotic government. A relaxation of despotism comes with advance in civilisation. Despotic government is still the rule, except among the white races. In Europe the government of Russia is practically despotic. Turkey, though nominally a European Power, preserves the despotic ideas of her Asiatic origin. With the exception of France and Switzerland, which are republics, the countries of Europe have



54. DENSITY OF POPULATION ALL OVER THE WORLD

hereditary rulers, whose power is more or less limited by constitutional safeguards. The characteristic form of government of the modern world is a federal republic under an elected president. It is universal in the New World, except in British, Dutch, and Danish Colonies.

World Powers. The nineteenth century witnessed a revolution in the conditions of transport. This has brought all parts of the world to within a few days or weeks of each other, and has led to the growth of world Powers, with colonies and dependencies in many parts of the world. The British Empire, the greatest in population and area, stretches through all latitudes, and is equally powerful in both the Old and the New World. Its constituent parts, where of white blood, are, with rare exceptions, permitted full self-government. Elsewhere the government is despotic, but extremely just. The Russian Empire extends across Asia to the Pacific, and is throwing out feelers towards the Persian Gulf. It is everywhere despotic. France has colonies in Eastern Asia and Northern Africa, and shows great organising power. Germany is creating an empire by acquiring territory in Africa and important interests in South America and Asia Minor [55]. Finally, the United States and Japan have both within the last few years acquired territory outside their own borders.

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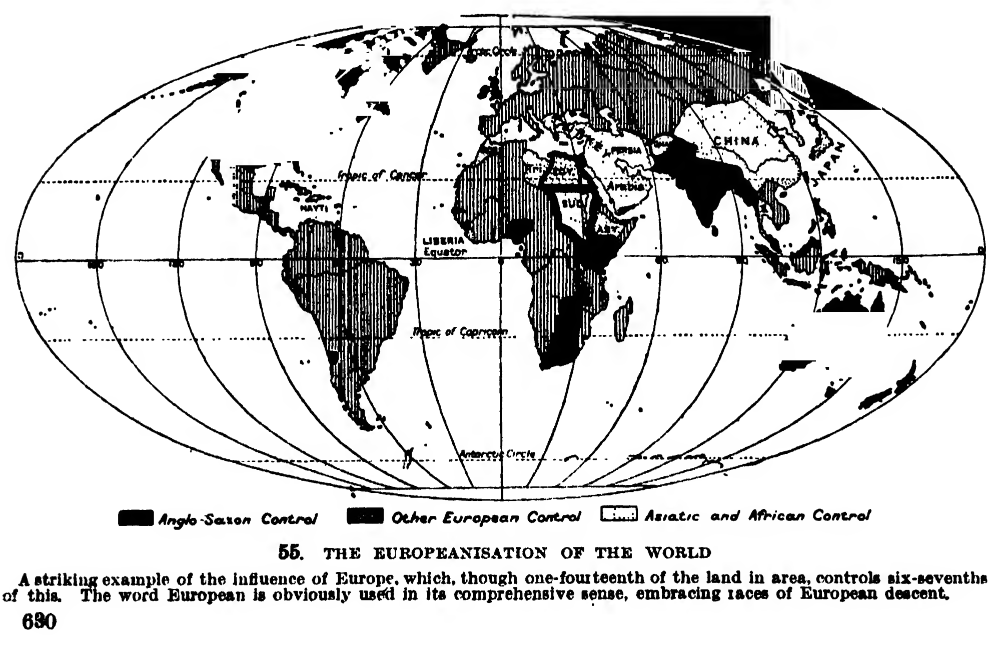


55. THE EUROPEANISATION OF THE WORLD

A striking example of the influence of Europe, which, though one-fourteenth of the land in area, controls six-sevenths of this. The word European is obviously used in its comprehensive sense, embracing races of European descent.

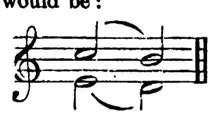
FIGURED BASS & COUNTERPOINT

Theory of Figured Bass. Choosing Harmonies. Counterpoint. The Fugue. Books to Study. Conclusion of "Musical Theory"

By J. CUTHBERT HADDEN

IN the old-fashioned pedagogic study of harmony, vast attention was paid to what is called "Figured Bass"—a kind of shorthand used by musicians, wherein the intervals which the notes of a chord form with its bass are expressed by figures. It is really of little practical value, for no composer begins by writing a bass to be fitted with harmonies; he begins with a melody, and sets harmonies to *that*. Nevertheless, the system of figured basses is still much used for students' exercises, and it is necessary to know something of the principles upon which it is founded.

Stated in a word, these figured basses are simply a system of interval measurement from the lowest note of the chord. Thus, a bass note to be accompanied by a common chord (eighth, fifth, and third) would be figured $\substack{8\\5\\3}$ or $\substack{5\\3}$. In practice, however, the common chord, being *so* common, is left unfigured, it being understood that an unfigured bass note is to bear a common chord. First inversions are figured $\substack{6\\3}$ or simply 6, second inversions $\substack{6\\4}$. A discord of the seventh is expressed by the essential figure 7, its inversions, in their order, by $\substack{6\\5}$, $\substack{4\\3}$, and $\substack{4\\2}$. A discord of the ninth (including a seventh) is figured 9, and the inversions 7, $\substack{6\\5}$, $\substack{4\\3}$, and $\substack{4\\2}$. The latter figures correspond with those for the inversions of the seventh, but the student can always distinguish a seventh from a ninth by the root note and generally by the resolution. When the same bass note is to bear two separate chords, the figures indicating these are always given. For example, if $\substack{6\\4}$ $\substack{5\\3}$ were placed below the bass note G, the result would be:



When accidentals are to be introduced, the necessary indication (sharp, flat, or natural) is placed before the figure representing the note to be affected, an accidental without a figure invariably referring to the third from the bass. Such are the foundation principles of figured bass. It is a very complicated system when taken in all its details, and in a work of this kind no good purpose would be served by a more extended exposition of it. Ninety-nine students out of every hundred want to "set" melodies, not basses.

And it is really much more difficult to choose appropriate harmonies for a given melody than to fill up a figured bass, which at best is a mechanical exercise. In setting about the harmonising of a melody, the student should give preference to the fundamental chords of tonic, dominant, and subdominant, either in root positions or inversions. It is by these major chords that strength and substance are imparted to a composition. But the three minor chords of the scale afford an agreeable relief, and these should be used along with the major chords as contextual and other conditions will allow, giving preference to the chord of the supertonic, next to that of the submediant, and last of all to that of the mediant. In the choice of inversions, be guided to some extent by the progressions of the bass itself regarded as a melodic part. Secure contrast whenever possible in the progression of the two most prominent parts of the harmony, so that if the melody moves by large intervals the bass shall move by small ones, and *vice versa*. A judicious mixture of discords will give still further variety, and the same may be said of passing notes, when the character of the composition will allow of their introduction. At first the student will often hesitate about the particular chords to use for the notes of his melody, for every melody may be fitted with a great variety of basses.

On this point we quote the late Dr. John Hullah. He says: "In the choice of roots for the several principal notes of a melody, its division into sections should first be ascertained; then the keys in which these severally end, and (as a necessary consequence) the cadences, perfect, imperfect, or plagal, of which their penultimate and ultimate notes form part. . . . In harmonising passages which modulate, or imply modulation, care should be taken, at the moment the modulation is about to be made, to use only such chords as belong both to the scale about to be quitted and to that about to be entered." In at least all his earlier attempts at harmonising, the student should always take means to put what he has written to the test of actual sound. Only in this way, and by a liberal use of manuscript music paper, can he hope to attain facility and success in the fitting of parts to a melody.

Counterpoint. The word *counterpoint* has a flavour of antiquity about it. And counterpoint is, indeed, a very ancient science, for it came before harmony strictly so called, and governed the art of musical composition well-nigh to the close of the sixteenth century. Nowadays the student who is well grounded in harmony often shirks counterpoint altogether, regarding it as superfluous. In any case it is customary to teach

harmony before counterpoint. The late Sir George Macfarren urged that students should reverse the process; that they should "master the laws of counterpoint, and so approach the fundamental or massive harmonic school by the path of history." This would be pedantic. The more usual method of teaching counterpoint presupposes a knowledge of harmony.

But what *is* counterpoint, and wherein does it differ from harmony? The word means literally "point against point" (*punctum contra punctum*)—that is, in modern terms, note against note. Notes were formerly termed "points," and adding a counterpoint meant setting one point or note against another. To combine notes—rather let us say melodies—one with another is the essence and aim of counterpoint. Every part must be of equal interest. This is how counterpoint differs from harmony. In harmony a melody is accompanied without special reference to the inter-relation of the parts. As a French theorist puts it, there is a material ready made to begin with—namely, chords. These the harmonist combines, modifies, links together; but they are always chords. Counterpoint recognises nothing of this kind. The chord is not a personality to the contrapuntist; he takes no heed of its name or its existence, and considers notes only in respect of their reciprocal distances, their consonance or dissonance, and their affinities. In a word, counterpoint is the art of combining *melodies*.

Simple and Double Counterpoint. Having thus cleared the ground, we proceed to a concise review of this somewhat abstruse art. The first thing to be noticed is that counterpoint is classed under the two broad divisions of "simple" and "double." When the parts are to be performed as they stand, the counterpoint is "simple"; when they are capable of being inverted, so that the higher part may become the lower, or *vice versa*, the counterpoint is said to be "double." Next, observe that counterpoint is divided into five distinct orders or "species." A "subject," technically called the *canto fermo*, is taken, and according to the manner of treating this subject, so is the particular "species" of the counterpoint. Here are the five kinds or "species":

First species. Literally "note against note"—*i.e.*, every note of the *canto fermo* accompanied by a note of equal value in the counterpoint.

Second species. Two notes—in triple time, three—against each note of the *canto fermo*.

Third species. Four, six, or eight notes against each note of the *canto fermo*.

Fourth species. With syncopations and suspensions.

Fifth species. Florid or figurate counterpoint, in which all the previous kinds are combined, with additional ornamentations.

Notice, next, that there is a *strict* counterpoint and a *free* counterpoint. In strict counterpoint (the older form) diatonic progressions are chiefly employed, discords being admitted only as suspensions or passing notes. In free counterpoint, on the other hand, all sorts of dissonances and progressions unknown to the strict style are allowed. Practically, it is part-writing in the modern style, for it is founded on modern harmony. In all counterpoint the means, compared with harmony, are vexatiously limited. Thus the only concords recognised are the octave (or unison), the perfect fifth, and the major and minor third and sixth. All other intervals are discords, including the perfect fourth when it stands between the lowest and one of the upper parts. Add to all this that each of the five species of counterpoint is written in any number of parts, from two to eight or more, each form (as regards the number of parts) regulated by its own special laws, and it will be seen how futile would be an attempt to encompass the subject in a work of this kind. Perhaps the best way will be to take two-part counterpoint of the various species, show by musical notation its actual nature, and state some of the rules which govern each particular species.

We have then the *first species*, where the added part is note against note of the subject. This is illustrated here by Cherubini:

In this species only consonances are used, the beginning being a perfect consonance, unison, octave, or fifth; the end a unison or an octave, preceded by the leading note.

In the *second species* we have two notes against one.

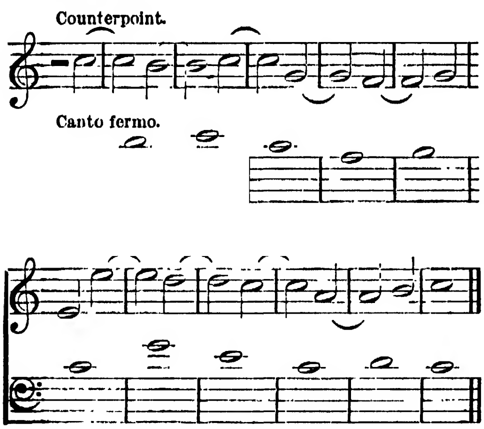
Here, again, the beginning should be with a perfect interval, and it is considered better to

start the counterpoint after a minim rest. The last bar but one should contain the leading note, preceded by the submediant if the counterpoint is in the upper part; by the dominant if in the lower.

The *third species* shows four quarter-notes in the counterpoint to the whole note of the *canto fermo*, as in the following example from Albrechtsberger:

In this species the first bar usually begins with a crotchet rest, and in the last bar the counterpoint note must be of equal value with the *canto fermo*.

In the *fourth* species the added part is in syncopation (tied notes) to each note of the *canto fermo*. Thus, in an example from Ernst Pauer:



The unaccented part of the bar, which always carries a consonance, becomes here, by the rhythmic displacement, the accented. The first measure of the counterpoint must contain a half-note preceded by a half-rest. The close is made by the suspended leading note, in the penultimate bar, and the tonic, a whole note, in the final bar.

The *fifth species* (florid counterpoint) is, from the composer's point of view, the most interesting of all. It is an absolutely free mingling of the four species preceding, to which may be added, for further variety, dotted half-notes and eighth-notes joined two by two. The following is an example:

These, then, are the five kinds of simple counterpoint. We have not quoted a third of the rules regulating each individual species. The first species, for example, is bound by something like a dozen separate restrictions, and if some of these are relaxed for the other species, new restrictions immediately take their place. The student, in short, will find counterpoint a very severe form of exercise. A French writer sympathetically describes the student of music as "feeling singularly hampered at first, and for some time scarcely able to move at all." But he will become accustomed to this, and later take great pleasure in what had at first appeared quite insupportable. The most exhaustive and up-to-date treatise on the subject is Professor Prout's, but the student will find Sir Frederick Bridge's primers in Novello's series of great practical value; also Dr. Pearce's "Student's Counterpoint" and "Composer's Counterpoint."

The Fugue. The *fugue* is the highest form of composition in counterpoint. All the "species" are employed in it, and a special "build" is imposed, from which there is no escape. The term is derived from the Latin, *fuga*, meaning "flight"; and the characteristic of a fugue is that the parts seem to be constantly flying from or pursuing each other. This was emphasised by the remark of a cynic, who regarded the fugue as a dry form of composition, that the parts "flew away from each other, and the listener from them all." The constructive elements of a fugue are made up of: (1) The *subject*, or principal theme; (2) the *answer*, at the fifth above or the fourth below; (3) the *counter-subject*; and (4) the *stretto* (Italian, meaning "narrow," "drawn together"), in which the subject and the answer are brought as close together as possible for the purpose of heightening the interest. There are accessory elements—episodes, counter-expositions, etc.—which, however, cannot be dwelt upon here. It will do the student greater service to quote the German theorist and composer Fux, who gives concise directions

for the construction of the fugue in its simplest form.

How to Construct the Fugue. "First (he says), choose a subject suitable to the key you intend to compose in, and write down your part in that part wherewith you intend to begin. This done, and having first examined your subject, to see that it be conformable to your key, repeat the same notes in the second part, either in the fourth or fifth; and while the second part imitates the first wherewith you have begun, put such notes in the first part as will agree with your imitating part, according to the directions given in the figurative or florid counterpoint; and after having continued your melody for some bars, regulate the parts thus that the first cadence may be made on the fifth of the key. Then resume your subject mostly in the same part you have begun with, but by another interval, after having first put a rest of a whole or half bar, which, however, may be omitted in case there should be a great skip instead of it. After this, endeavour to bring in your second part, after some rest, and that before the first part draws to a conclusion; and having carried on your subject a little longer, make your second cadence in the third of the key. Lastly, introduce your subject again in either part, and contrive it so that one part may imitate the other sooner than at first, and if possible after the first bar, whereupon both parts are to be united, and the fugue finished by a final cadence."

Examples of the Fugue. These are abundant in classical music, for every composer has written something in this form. The greatest of all fugue writers was Sebastian Bach, whose "Forty-eight Fugues" and other numerous organ and choral fugues, monuments of constructive genius, ought to be familiar to every student of this most scientific branch of musical composition. Bach, as an acute critic remarks, understood how to unravel all the scientific and artistic mysteries, to throw life, fluency, grace, and charm into his fugues; and he alone was able to present an almost unceasing variety of subjects, while he possessed inexhaustible means of enriching the beauty and power of his themes. There is an admirable little work on Fugue by Mr. James Higgs (Novello), which the student will find helpful.

Musical forms can be dealt with only very briefly. The *sonata* is the most important of the instrumental forms. According to modern use, it has generally four separate movements—the first in the elaborate so-called sonata form; the second in some slower time; the third a minuet; and the fourth (the finale) usually a rondo. The second and third movements are interchangeable. Each movement may be said to form a separate composition, and yet possess a connection with the other movements. "A certain unity of feeling must pervade the whole." The masterpieces in this form are chiefly the work of Beethoven, Haydn, and Mozart. The structure of the sonata applies also to the *symphony*, in which a certain number of instruments are united "to produce a poetical representation of a series of emotions of the soul." It has a broader and grander treatment than the sonata, as witness Beethoven's "Pastoral" or "Eroica" symphonies, compared with any of his sonatas. In the *concerto* we have a piece in three movements, in which one particular instrument (piano or violin) is regarded as the solo instrument, and is accompanied by a small or larger orchestra. The *overture* stands half-way between pure symphonic art and musical dramatic art, and is derived from both. Its object usually is to "prepare the spectator for the emotions of the drama which is about to be performed in his presence by placing him in the mood most suited to receive the impression vividly." Hence it is often constructed out of the material of the work itself, or filled with allusions to its principal themes.

Books to Study. Such are the leading instrumental forms. It would be impossible to describe in detail the form of the chant, the chorale, the anthem, the part-song, glee, and madrigal, the march, the various dance forms, the suite, the rhapsody, the string quartet, the fantasia, and the variation, to say nothing of extended works like the opera, the oratorio, the mass, and the cantata. Some of these are briefly described in the glossary on page 42. For fuller details the student should consult such works as Ernst Pauer's "Musical Forms" (Novello), or the articles under the various headings in Grove's "Dictionary of Music and Musicians."

We thus conclude our survey of the theory of music. With the more advanced branches of the subject it has necessarily been a case of merely placing the student on the road leading to the heights. Much that a Beethoven and a Wagner knew has perforce been omitted. But the foundations have been laid, and with the aid of the more exhaustive works of the theorists the student can readily rear his superstructure. Professor Prout, our greatest living master of theory, has completely covered the subject in a series of works which are unrivalled in any language. To these the student aiming at the very highest attainments must be referred. The musical theory books are legion, but none are better, none more exhaustive, than those of Professor Prout.

Continued

THE FARMER'S SEEDS

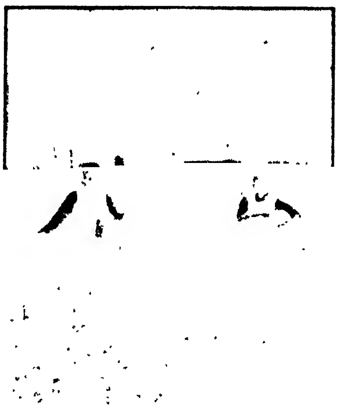
Construction of Seeds. How to Sow. Efforts for Light and Air. Effects of Wet and Cold. Weight of Seed. Increasing the Crop

Group 1
AGRICULTURE
5
Continued from page 590

By Professor JAMES LONG

SUCCESS in agriculture in the future lies in the application of scientific method. The young farmer who would succeed beyond his fellows will do well to ascertain, by confirming facts for himself, and by simple methods of observation and experiment rather than by reading or hearing, how seeds are constructed, and how the embryo plant within the coat is enabled to germinate, to feed, and to grow. The remarks which follow will, it is hoped, not only afford him some assistance in these directions, but enable him to carry out some such process of acquiring knowledge at first hand, although they are necessarily limited.

The Plant's Start in Life. A seed has been described as a miniature plant, although it is something more, for it contains sufficient food to give the tiny living organism a start in life, until, indeed, by the development of its roots and its leaves, it can shift for itself. The seed is developed from the flower, and it is as interesting as it is instructive to watch this development from day to day. Seeds differ in form, size, and structure; they differ also in that while some germinate at a relatively low temperature, others will not. The range of temperature, which applies to the seeds of farm plants, is broadly between 40° F. to 100° F. Thus, while 65° F. to 70° F. may be regarded as the most generally suitable on the farm—although germination is more rapid at the higher temperature—it fails altogether beyond the extremes mentioned. The germination of seed, too, depends much upon the depth at which it is sown. Few seeds will grow when deposited six inches below the surface, while the deeper they are sown within this range the longer they are in making their appearance, and the larger the number of failures.



BROADCASTING THE SEED

Seeds should be sown as nearly as possible at a specific, and always regular, depth—the depth depends upon their size and their variety. It is quite common, for example, to broadcast very small seeds, such as those of the grasses and clovers, on the surface, and to cover them with the harrow. The result is that many remain uncovered, and, being induced to germinate or sprout by contact with the moist soil, many are subsequently malted or killed by the sun. This is an important point to note. Such seeds should be covered by at least half an inch of fine soil, and subsequently pressed with the roller to provide them with a compact bed.

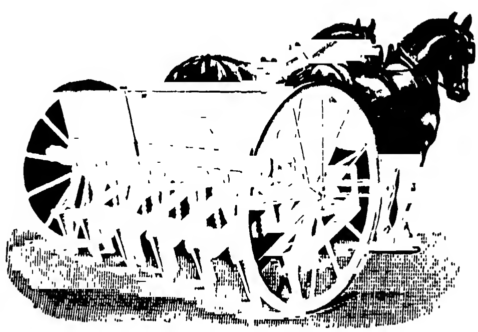
The Behaviour of Seed. Farm crops are nearly all grown from seed, much of which is impure or so lacking in vitality that it fails to germinate or to live. The process of germination and subsequent growth may be observed by the adoption of one of many simple methods. A hundred seeds, preferably those of barley or oats, may be placed upon a porous tile or saucer—preferably one of those employed in a seed-testing station—which is allowed to stand in a larger saucer well supplied with water. As the water rises and comes into contact with the seed, the latter swells and sprouts, thus proving that moisture is essential to germination. This, however, is not all; the seed must be in contact with air, which must be sufficiently warm—as in the living apartment of a house—for, as we have seen, it will not germinate at a low temperature. In a few days it will be possible to count the number of worthless seeds, and, consequently, to ascertain the percentage of germination. By observing the process of growth, the *radicle*, or root, and the *plumule*, or stem, will be recognised, while in due course the leaves will appear.

An Instructive Experiment. A still more instructive experiment may be made, and this time by the aid of seeds of much larger size. We take the broad bean, which for this reason is usually employed in demonstration, and we plant a number of seeds side by side in fine deep soil, at various depths, ranging from 1 to 6 in., several seeds being planted at each depth. From day to day we take up one seed at each depth, and examine its progress. We note the temperature of the soil, and subsequently the rapidity of germination. We find that, as before, the root and stem appear, but that, unlike the oat, the entire contents of the husk or shell of the bean is practically composed of what we subsequently recognise as seed-leaves, but which are known as cotyledons. These leaves provide nourishment for the young plant, whereas in the case of the oat and other cereals, this food is found in the flour which forms the bulk of the seed, and which is known as starch. Plants, however, being unable to feed upon solid materials, Nature provides a method, through

the medium of a ferment known as diastase, of converting the starch into sugar during the process of germination. Sugar being soluble, is therefore easily appropriated.

Influence of Light and Air. It will be noticed that however the beans are laid in the soil, the stem grows upwards towards light and air. If we exclude air, growth is prevented, while if we exclude light, we shall find the leaves retain the whiteness of colour which always distinguishes them before they emerge from the soil. The green colour of the leaf is owing to the presence of a colouring material known as chlorophyll. It has been remarked already that the plant, after germination, is fed by food stored within the seed. This food is quickly exhausted, but it so far enables the seedling to develop its plumule and leaves, and its radicle, that it may be placed in a position to obtain food for itself from both soil and atmosphere.

We have seen that the seed is stored with starch, upon which, after conversion into sugar, the seedling is fed. Starch, like sugar, is known among feeding materials as a *carbohydrate—i.e.*, it is a compound of carbon, hydrogen, and oxygen, the two latter elements existing in the compound in practically the same proportion in which they are combined in water—*i.e.*, two parts of hydrogen to one part of oxygen. Starch, like sugar and other carbohydrates, is thus air-derived, the elements of which it is composed being appropriated by the leaves of plants. If a piece of sugar or starch be burnt, nothing remains; the elements of which it is composed have returned to the atmosphere.



SEED DRILL

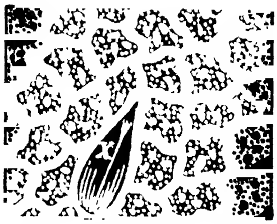
The Plant's Food Supply. If a seed has germinated, and is allowed to remain exposed upon the tile or saucer to which we have referred, the seedling will die when its food supply has been exhausted. Similarly, if we deposit seed within pure sand which has been calcined to destroy any nutritious matter that it may contain it will germinate and grow until, having exhausted its store of food, it withers and dies. On the other hand, if the sand be mixed with small quantities of the minerals with which plants are normally supplied by the soil, together with a small portion of fertile soil, which will convey the necessary bacteria, a leguminous plant will flourish, for it will then be able to obtain its nitrogen from the atmosphere. When seed is deposited in fertile soil, germination following, the plant grows because it is supplied with food; but its size, vitality, and growth depend upon the soil being furnished with a regular supply of food, and especially in that the soil has, by cultivation, been brought to such a fine condition that the tiny plant rootlets are able to seek and appropriate it.

Thus, if we compare the beans which have been planted as an experiment with others which have germinated in a saucer, we shall not only be able to ascertain the influence of depth and of temperature, but we shall observe that the growth of the former is owing to something which they find in the soil, and which is not available to those growing apart from it, only to die when they have exhausted the food which the seed provides. If seed be deposited in cold, wet soil, the temperature being below germinating point, it may remain intact, especially in the case of oily seeds, like those of the weed known as charlock, or wild mustard; or it may die and rot.

When wet and cold weather follows early winter sowing, it frequently happens that a large proportion of the seed fails to germinate, and is spoiled; hence the importance of draining and improving the porous character of heavy soils. It is proverbial that where seed is sown unusually early or late, a larger quantity is required to ensure a normal crop. This may be partially owing to failure to germinate, but it is chiefly owing to the depredations of birds and vermin, which make greater inroads upon a seed-bed during these seasons than during the main sowing season, when a much larger area is available to them.

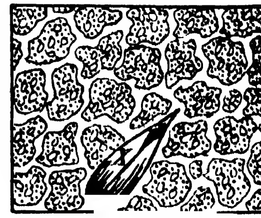
How to Recognise Good Seed. It is important to learn how to recognise a good sample of seed. Without an actual test it is often impossible to distinguish fertile from infertile seeds, and in some cases a farmer of experience may fail to differentiate between pure and impure seeds. It is, however, of primary importance to distinguish between a good sample and a bad sample from bulk, whether in hand or in the sack; and in order to do this there is nothing like practical experiment—actual comparison between known fine samples and known impure and imperfect samples. If comparison be made in the presence of an expert who points out the differences in colour, size, and general characteristics, so much the better for the novice.

It is important that seed should not only be pure, but full of vitality, and consequently that it should be new and in good condition. The brownish imperfect colour in the oat, for example, indicates that it may have heated in the rick, and its vitality destroyed. All grain should be bright, pure in colour, clean, sweet under the nose, and up to weight. There should be a minimum or, indeed, entire absence of thin, small grains, which are quite common in samples



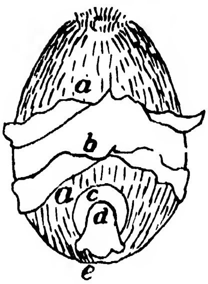
1. Seed in soil with water but without air.
x Seed. Black: Water. White: Powdered soil.

2. Stony and cloddy ground. Seed. *y*. Hard clods. *z*. A stone.

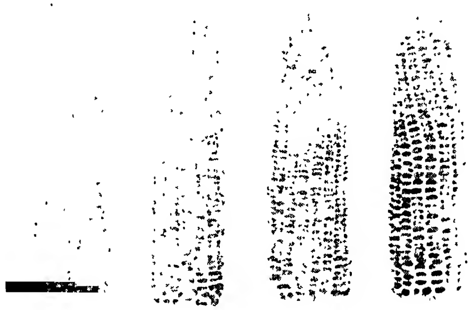


3. Seed in soil with air but without water.
x. Seed. Dark spaces: Air-filled pulverised soil. White: Air.

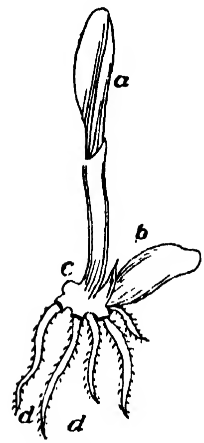
4. Seed in soil with air and water.
x. Seed. White: Air. Shaded parts: Powdered soil. Black spots: Water.



5. Wheat grain.
a. Outer skin.
b. Inner skin.
Scale or Cotyledon.
d. Rudimentary plant.
e. Junction of all the above.

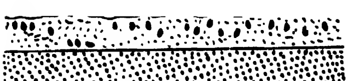


A. B
6. Improvement of Maize by selection.
A. Developed heads. B. Original heads.



7. Wheat germinating.
a. Shoot leaving its sheath.
b. Shoot evolved.
c. Unevolved shoot.
d. Rootlets.

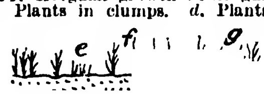
8. Seeds in furrow.
a. In hollows. *b*. On tops and sides of furrows.



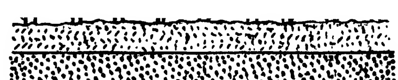
9. Seeds on badly-ploughed furrow.
e. Clustered seeds, shallow covered. *f*. Clustered seeds, buried deep. *g*. Scattered seeds, shallow covered. *h*. Scattered seeds, deep covered.

10. Seed sowed by drill at regular depths.

11. Irregular growth on irregular furrow.
c. Plants in clumps. *d*. Plants scattered.



12. Irregular plants on ill-ploughed furrow.
e. Late plants. *f*. Early plants. *g*. Regular plants.



13. Regular growth from drill-sown seed.

SEEDS AND SOILS
Showing the result of scientific method in modern farming

of second-rate oats. No better object-lesson than the seed classes at an agricultural show, such as Birmingham, which may be studied with great advantage, can be suggested. Clovers and grasses are in particular liable to impurities and adulteration, and special care should be taken in their selection.

Buying Seed. In buying seed it is wise to deal with the best firms, and to obtain guarantees with each purchase. That the price is a little higher than that charged by seedsmen without reputation is not to be considered. A buyer must expect to pay for the extra trouble which a guarantee of purity involves. Suppose we count a hundred seeds, and find 20 per cent. of the sample to be impure. And suppose, further, that of the 80 per cent. of the seeds remaining we find on testing for germination that 25 per cent. fail. In such a case we obtain only 60 per cent. of good seed, the cost of which may have exceeded that charged by the seller of a guaranteed sample. The cost of seed which is both impure and wanting in vitality is oftentimes enormously greater than that of apparently costly guaranteed seed. If it be inconvenient to make a test of a purchased sample, the buyer should communicate with the Secretary of the Royal, or some other important agricultural society, that a test may be made for him by the expert retained for that purpose, and he will have the advantage of a semi-official report at a very nominal cost.

Weight as a Guide to Value. Weight of seed is a guide to its value. For instance, oats weighing 36 lb. to the bushel are more or less common on the market; but, apart from the impurities they contain, there are many small oats almost entirely or quite devoid of kernels. The mere husk is useless, while small seed with a tiny kernel is next to useless, for it cannot produce a fine prolific plant. Oats for seed should weigh from 40 to 42 lb. to the bushel. Weight is significant, inasmuch as it means that the seeds are robust, and if well saved, full of vitality, and that they contain abundance of food for the nourishment of the seedling plant. The weight of seeds will, however, be referred to in the chapters dealing with agricultural plants. The testing of seed has long been conducted at the Swiss station at Zurich, by Dr. Stebler, whose work on the subject is of the first rank. There are also public stations in Denmark, Sweden, and the United States, and it is significant that in the absence of a British official station, the station at Zurich has been long and largely supported by British growers.

The Life of Seed. It is important to notice that the life of seed varies considerably. While the seed of the cabbage and the swede retain vitality up to six years, or even more, it is unsafe to sow the seed of oats, spring wheat, or barley which is over two years old. Much depends upon how seed has been kept, but in practically all cases the number of seeds which germinate after sowing diminishes with each year of its age. It is, therefore, the safest plan to insist on new seed. With reference to germination, it is necessary to point out that the best seed may fail in a bad seed-bed. The soil should, therefore, be fine, deep, and well compressed after sowing. A coarse bed may leave some seeds lying in open spaces, where, after germination, they are liable to die. In order to be well equipped with facts relating to the behaviour of seeds during and after germination, the learner should make experiments with cereal, clover, mangel, turnip, and grass seeds, similar to those to which we have referred in the case of the bean, always remembering to avoid a wet soil—in which the seed may be damaged or destroyed—and a very dry soil, in which it may long lie before germination.

Uses of Seeds. The seeds of plants commonly supply food for men and animals, as in the case of cereals and pulses, linseed and cottonseed, the two last named supplying oil for industrial and other purposes, while the residue remaining after pressure provides food for farm stock. All seeds contain the nutrients known as the carbohydrates—chiefly sugar and starch—fats and oils, also remarkable for their richness in carbon, and the proteids, which, in addition to the elements already named, contain abundant nitrogen. The seeds of plants, therefore, play a double role; they are responsible for, and essential in, the production of crops, while they provide the most valuable and concentrated foods which are supplied to the animals consuming those crops.

The majority of farmers regard a change of seed from time to time as essential to the success of their crops. The work of the experts employed by the Government of Canada has practically proved that this change is not essential, and that the only method of increasing the crop from the point of view of seed influence is to breed—*i.e.*, to produce seed on the principle of selection. The method which has now been adopted for some years is practically as follows:

Increasing the Crop. The strongest plants of the most suitable variety known on the farm on which it is grown are selected before harvesting or cutting. The ears of these plants are separately collected, and in the case of grain the corn is threshed and dressed, the heavest grains alone being retained. These grains are subsequently sown on a specially prepared seed-bed, enriched with manure with the object of producing fine strong plants which will bear equally fine and robust seed. Before harvest arrives the best plants are again selected, and subjected to the same treatment, the finest seed alone being retained for sowing, and so from year to year the seed, instead of being saved from the main crop, is produced from the best seed grown upon the best ears sown in a special seed-bed.

The principle is applied equally to pulse, clovers and potatoes, with the very best results. These results are superior to any obtained in any other way, and they can be confidently followed, inasmuch as they are based upon the clearest of scientific principles.

Continued

THE VAST FORTUNES OF TO-MORROW

Continued from page 521

Where they will be Made. Waste Utilisation. Cheap Ozone. Artificial Silk. Forestry. Photography. Food-stuffs. Entertainment

By ERNEST A. BRYANT

THE man whom we call the greatest creative genius is in reality the most versatile plagiarist. He reads the book of Nature, and in a thousand ways applies her wonderful lessons. He gives practical effect to cardinal principles; he utilises concrete examples. The greatest lesson of all he is still learning—the lesson that in Nature there is no waste. The credulous native who venerates a plant or rock as embodying one of his departed ancestors has more of fact on his side than is commonly credited.

The idea was well expressed by Lord Playfair when he said: "The economy of the chemistry of art is only in imitation of what we observe in the chemistry of Nature. Animals live and die; their dead bodies, passing into putridity, escape into the atmosphere, whence plants mould them into forms of organic life, and these plants, actually consisting of a past generation of ancestors, form our present food."

The New Meaning of Waste. Man, then, taking this lesson to heart, is evolving a new meaning for the word "waste." The refuse of yesterday is the potential wealth of to-morrow. Sawdust, which anciently had no use except as pack ng for unsatisfactory dolls, is now made to yield alcohol; or to form, when mixed with blood from the abattoir, imitation ebony, wheels for roller skates, and other useful articles. One patient speculator seeks to convert it, by compression, into planking. Coal-smoke has in it the elements of wealth; from it there may be extracted industrial alcohol and other marketable products. One firm has already made it return 10 per cent. of lead which was previously precipitated into the atmosphere.

There is undreamed wealth in the refuse-heaps which disfigure the neighbourhoods of blast-furnaces and collieries. Lovers of the countryside are attempting, by planting them with trees and shrubs, to obliterate these hideous blemishes by which the landscape is scarred. But the day may come when the trees now being planted will be uprooted in order that wealth may be extracted from the heaps now despised.

Power from Blast Furnaces. Every year some 18,000,000 tons of slag are produced by the blast-furnaces of Great Britain. Already an industry has grown up around these miniature mountains. But the possibilities are not nearly exhausted when, so far, we get only ballast and slag-wool. The blast-furnaces themselves permit the escape of enormous volumes of energy which we must learn to conserve, so that it may furnish such districts with artificial heating and lighting, and with power to drive the machinery of the towns, their trams, and trains. An example of what may be accomplished in this direction is afforded by a great firm in the West of Scotland. Fifty per cent. of the coal which they consumed, it was found, was permitted to escape in waste; gas was dissipated in sufficient volume to light a dozen towns. Ingenious minds devoted to the problem devised plant whereby now they derive power for driving all the machinery to collect the tar and break it up for use as fuel oils; pitch for use as fuel; ammonia to the extent of half a ton a day. Altogether, what was absolute waste is converted into a net profit of over £20,000 per annum.

A Pure Water Supply. If it be true that dirt is matter in the wrong place, it is equally true that waste is waste only to those who have not brains or sufficient energy to resolve its elements into useful form. One of the problems by which scientists of to-day are faced is the treatment of sewage and the purification of water supply. Yet it is acknowledged by the highest authorities that the most noisome residuum with which we have to deal is the very product necessary for the maintenance of fertility in the soil of Europe.

And we must be upon the eve of solving the question of pure water supply. While the present paper was being written London was still considering the statement of one of its Medical Officers of Health to the effect that we must no longer look to the Thames as a supply of water for drinking purposes, as the river has become hopelessly polluted. It is a statement of this kind which gets things done. Not until members of Parliament were threatened with fever from the stench of the Thames did we get the Embankment in place of the malodorous foreshore which was slowly poisoning London. When the Thames is pronounced impossible of purification we may hope to see it purified.

Nice sets us a brilliant example. Its water supply has long been a danger to health. Now, while this paper is in course of preparation, the authorities there have embarked upon a scheme for the ozonisation of their drinking water—9,000,000 gallons of water per day are to be ozonised. No drink is purer than ozonised water. The process kills every deleterious organism in the fluid. Setting at defiance cholera, typhoid, diphtheria, it promises to give us from the Thames water of which the most delicate may safely drink. But the benefit does not end here. By its aid the atmosphere of the hospital ward, the sick-room, the public hall and theatre may be purified.

Cheaper Ozone. What we want now is a cheaper process of ozonisation. Cost is at present the only barrier. When the man with

an economical method comes forward there will be no reason why every tram and train, every office and shop, every establishment in which we eat our meals, should not have its due supply of invigorating ozonised atmosphere. But, even now, only the fringe of the subject has been touched. The commercial possibilities of ozone are infinite. Ozone, when we get this cheap process, may banish chemicals from the bleaching-house. Cotton and paper will be bleached by its aid. Delicate fabrics inevitably suffer by chemical bleaching; there is at present nothing to equal the primitive old method of bleaching by the aid of the sun. The country housewife shows her knowledge of this when she lays out washed linen to dry in the sun on hedgerow and grass-bank. Ozone will bleach as effectively as the sun, but in one-thousandth of the time.

The need for a new process of paper manufacture for art work has already been considered. It may be added here, at the suggestion of a noted chemist, that in the course of the next 20 years the surface of the highly-glazed art papers at present in use will be practically destroyed. Paper-making is an industry more and more claiming attention. Rag paper for newspapers is too costly; certain grasses now in use yield too brittle a result; the forests to which we look for wood-pulp as a source of supply are rapidly disappearing. A new supply is badly needed; it is coming already from Newfoundland. The stalk of Indian maize, so long a curse to the cultivator, is now being successfully employed for the purpose. Millet, of which enormous quantities are grown, serving already to its cultivators as many purposes as the reindeer serves to the Eskimo, may have yet another value as a base for paper manufacture.

The Butcher's Laboratory. Nature is an insistent mistress. When we cast aside residual products as useless, she has a habit of making the refuse so intrude upon our attention that out of very vexation and despair we are impelled to take note with a view, not so much to utilisation as to disposal. The cotton seed was long the plague of the planter's existence; to-day it is a gold-mine to him for conversion into oil and cattle-food. So it was with the refuse of the slaughter-house. But what a miracle of adaptability the modern scientific butcher has become! He makes the bullock yield from by-products so many articles of value that now we are assured by the Beef Trust that the bullock is not worth cultivating as beef; that the profit comes only from materials which, but the other day, were a waste and an offence to our olfactory nerves.

Those who will may believe it, but just as Manchester, by the intelligent application of unpleasant matter to its proper use, has converted a sterile bog into a smiling estate, yielding food for the many, so the butcher takes the carcases, element from element, and metamorphoses them into combs, buttons, pipe-stems, handles, tooth-brushes, powder-puffs, billiard balls, meat extracts, tonics, sugar, gelatine, oil, soap, pepsin, and fertilisers.

Lord Masham's vast mills at Manningham are an even more attractive example of the application of brain-power to the mastery of commercial problems. It cost him only a penny per pound to buy the great mass of sticky, dirty waste left after the cocoons of silk had been unwound; but he had spent a quarter of a million sterling before he had mastered the secret which that filthy heap contained. That quarter of a million, and all the time he devoted to it, have since then yielded fortune upon fortune to him, and prosperity and relative wealth to a large population at Manningham.

A Romance of Textiles. We want more of these scientific men in commerce. The great masters in the textile trades have done practically all that is possible with the materials at their disposal. They want now new fibres for clothing and other textile purposes; ramie, it is said, is to become a chief textile of the future. Distillers want new processes, enabling them economically to utilise all their residual products. Scientists want the man who, with a mental divining-rod, will guide them to refuse heaps or natural deposits whence they may extract radium. Some day the Queen of England may wear a dress of silk spun, not by the worm, but by human hands. There are three processes already in operation in England, and increasing attention is being given to the subject.

Centuries ago James I. endeavoured, unsuccessfully, to acclimatise the silkworm here; now, after the lapse of all these years, there seems a possibility that we may challenge France in the production of silk. Those who are working at it modestly disclaim the hope of rivalling the natural product, but there is good reason to believe that the man may come who will give us an article so beautiful and durable that the proudest lady in the land will not be ashamed to wear it. This, of course, would open up quite a new industry for England. And that is an important consideration. Every discovery which makes its mark upon the commerce of our country means addition, not only to the wealth of the individual, but to the earnings and comfort of the community.

Two Industries from an Experiment. It has been already noted how the approximation of various branches of industry, hitherto regarded as widely separated, is creating wonderful developments. Lace, muslin weaving, netting, and hosiery are coming together. It is fascinating to trace the development of industry from industry; to note how two or three come together, and then others branch out in wholly unexpected directions. How important these developments may be can be seen from this very question of the artificial production of silk. One of the processes mentioned was the result of experiments tried with a quite different end in view. The object was a solvent for cotton, whereby the latter might be converted to various uses. The cotton having been changed to liquid form, the time came when it was found possible to spin it, in its new form, just as the silkworm spins. But the wonder did not

end here. When the liquid set, it was found to provide an excellent filament for incandescent gas-mantles! Here, then, are two new industries from one and the same experiment. Need we, after this, despair of converting a ball of worsted into a navigable airship?

Fortunes to be Made in the Forest. A subject of national importance to this country is forestry. It is, of course, a sound argument that where forests are, crops for the food of man cannot be. But, then, those who advocate afforestation do not plead their cause at the expense of arable and pasture land, any more than those who advocate the multiplication of pretty toys for children would care to destroy the manufacture of mathematical instruments. We spend between £20,000,000 and £30,000.000 annually on imported timbers. Some little share of that might go into the pockets of thousands now leaving the land in this country were it possible to conduct a scheme such as they have, say, in Germany. Their forest industries represent excellent wages to several hundred thousand families, aggregating in all some three or four million people. These find employment in wood-turning, carving, coach-building, match-making, wood-pulp manufacture for paper, drum and cask hoop-making, the manufacture of wooden rivets, spoons, shovels, and toys in endless variety.

The afforestation of catchment areas in Great Britain has an important bearing upon pure water supply; and the attention of the student may be directed to the experiments of Liverpool and of some other corporations now in progress.

Toys. Apropos of toy-making, there is no reason why great firms in whose premises carpentry, cabinet-making, and the like are carried out on a considerable scale should not add to their income by establishing departments for the manufacture of toys and bric-à-brac; the débris from the lathe and bench is just the material, now wasted, which would serve for the purpose. Birmingham ought to claim a larger share in the home market for mechanical toys, of which hundreds of thousands are annually imported at prices ranging from a penny to a half-crown. America is setting up her toy-works in conjunction with larger enterprises; and she has no monopoly of the executive skill necessary for the work. Here, however, as in many other directions, she gives the lead to the Old Country, where, so long have we enjoyed commercial ascendency that we are averse to adopting new schemes or new implements. Yet it is only by assimilating new ideas, instead of condemning them untried, that we shall reassert ourselves anew in the markets of the world.

Mention of toys suggests other possibilities for the children. An American firm finds it worth while to place on the market a contrivance for the rapid blowing of soap-bubbles. If that, in the judgment of acute men of business, be a sound investment, other ideas of a similar character might safely be tried in this country. Of the millions of children who go each year to the seaside, all, rich and poor alike, have at their disposal only the same old sources of amusement. Adults complain of the deadly dulness of the seaside; for the children the conditions are still worse.

A New Seaside Industry. Spade and bucket serve to-day as spade and bucket served when our grandparents were children, Castle-building, with moat and trench, are the joy of the children on the sands. Spade and bucket are but primitive tools for the work. A simple implement for "mining" sand—something which would make a trench at a stroke, if need be—is the thing wanted for the beach. There is a whole armament of new toys for the seaside to be made by the man who cares to undertake the thinking. Another phase of seaside life affording openings should appeal to what we may term "the children's Grossmith." Pier entertainments are not, as a rule, for children; and too often the "niggers" and pierrots are recruited from the ranks of itinerant vocalists who, out of the seaside season, wail for pence at the doors of public-houses, and take their pot-house "humour" with them for the summer to the sands. An entertainment on the beach or the pier which would appeal to children and be absolutely free from offence would be a boon indeed.

An All-day Entertainment for London. The same style of entertainment is needed for children in London. And older children would welcome harmless amusement. London with its ever-swelling throngs of pleasure seekers should support at least one place of amusement at which visitors could drop in for an hour at any time of the day. We have many theatres and variety halls, but where, east of Charing Cross, can entertainment of the character indicated be obtained, and where, even in that part of London, save at one hall? Sight-seeing palls upon even the most eager seeker after knowledge; he would pursue his way with the greater avidity after an interregnum devoted to rest and recreation in a hall where for an hour he had listened to good music and laughed at a really humorous song. The experiment of giving four performances a day has been tried at one London establishment, but discontinued after a few months. In conditions demanding less expense in production the venture ought to prove successful. It costs no more to have open a hall in which is a concert-platform than to keep it closed. And where there is entertainment to be had, London visitors will go—and be thankful. London should provide fortunes for many Grossmiths if they would afford her the opportunity. After this digression the matter must be left, while attention is given to more material considerations.

We have a tremendous object-lesson before us in the story of aniline dyes. There is still living in our midst, in this fifth year of the twentieth century, the man who has given incalculable fortunes to the world. Dr. W. H. Perkin was experimenting with a refuse—coal-tar—when he discovered the first aniline dye. Science knows no country, it is pleasantly said; but, unfortunately, one country knows science a good deal better than

another. And the discovery of this great Englishman was seized upon by the German chemists. The secret had been laid bare in England, but our system was not capable of developing it, and almost entirely the millions upon millions sterling which it represented have passed into German keeping. We export the raw materials for the work, and the Germans sell us the finished article!

An English Idea Which Made Germany Rich. All the most exquisite essences, all the dainty perfumes for the toilet-table, all the delicate odours for our best soaps; saccharine, hundreds of times sweeter than sugar and realising a fabulous price; carbolic acid, and all our best disinfectants; with, of course, all our finest dyes, result entirely from the discovery made by this English savant. He placed us first in the field, and the incalculable wealth which his discovery portended might have been ours exclusively but for the characteristic inefficiency of those who should have been ready to seize and develop the idea. It is questionable whether a nation has ever before been so vastly enriched by the discovery of an individual as Germany has been from the discovery of Dr. Perkin. They deserve their gains just as they deserve the success which attends their manufacture of artificial indigo; deserve it because they systematically sought to develop and best turn to account the new idea. But they have killed India's indigo trade, and they make England buy German essences and dyes.

In the same way Great Britain, whose coal-beds are the finest yet discovered, has had within the last two years reluctantly to follow where the Continent and America have led in the matter of mining coal by machinery. Many mines have been shut down here as no longer profitable because seams had run thin or the coal was too hard to be profitably mined. The coal-cutting machine can work at a rich profit seams which could not have been touched by the labour of man except at a heavy loss to the mine-owner.

Photography in the Future. Another respect in which we have lagged behind is photography. Great as is the advance made within recent years in England, the art is still only in its infancy. The world is still awaiting the advent of the man who shall photograph colours, and print them from one negative. There are a thousand and one appliances which the photographic operator wants. He wants simpler methods of developing and printing and fixing. Delightful work as it is, the time now required for the developing of a series of negatives in the dark-room is too long, as well for one's limited leisure as for his health. Daylight developing is now practicable with a certain outfit; it is wanted for all. It should not always remain impossible to develop by "dry" methods. The wet plate has long been improved out of existence; the time has come for liquid developers to follow suit. The same remark applies to toning and fixing. These processes are at present too slow and irksome. The man in the roadside booth manages in a few minutes to produce a permanent portrait—of a sort; but the first-class photographer cannot. Speedy work, especially for the illustrated press—a goldmine to the photographer—is a feature of increasing importance. Photography in future will be much more common for commercial purposes. It will be more and more used in the office as an adjunct to machine-drawing, a circumstance which should be borne in mind by the student. There is also a future for photography, experts declare, in advertising.

Food-stuffs claim the attention of the chemist. A thousand things are rejected as waste from industrial establishments which can be made digestible and nutritious for cattle and poultry. For human beings there is a certain sentiment against converting waste products into alimentary delicacies, but our great chemists frankly state that we must in the future look with increasing expectancy to the laboratory for sustenance, and that into those laboratories more and more men with brains and originality will have to go. The manufacture of artificial butter and margarine, which no one would have dreamed possible a few years ago, is now rapidly becoming an important industry. And other food-supplies will have to be augmented by similar means.

Chemistry, the Prudent Housewife. Waste must be no longer waste in the old sense. We have advanced immeasurably since Lord Playfair opened our eyes to what was happening in the laboratories of the world when he said: "Chemistry, like a prudent housewife, economises every scrap. The clippings of the travelling tinker are mixed with the parings of horses' hoofs from the smithy, or the cast-off woollen garments of the poorest inhabitants of a sister isle, and soon afterwards, in the form of dyes of brightest blue, grace the dress of courtly dames. The main ingredient of the ink with which I now write was possibly once part of the broken hoop of an old beer-barrel. The bones of dead animals yield the chief constitutents of lucifer matches. The offal of the streets and the washings of the coal-gas reappear carefully preserved in the lady's smelling-bottle, or are used by her to flavour blancmanges for her friends."

All this was wonderful when Playfair was in his prime, but we have left far behind the outposts of the applied science of which he in his day was so brilliant an exponent. The student of to-day has at his disposal more knowledge of applied science than had the man who taught the subject to the present King of England.

Continued

VARIOUS BUILDING MATERIALS

Including Bricks, Tiles, and Terra-cotta, Pipes, Sand, Gravel, Lime, Cements, Plasters, Mortar and Concrete

Continued from page 535

By Professor HENRY ADAMS

Bricks : Size and Composition. Bricks are artificial blocks averaging $8\frac{7}{8}$ in. long, $4\frac{1}{4}$ in. wide, and $2\frac{5}{8}$ in. thick, moulded from a loamy clay called brick-earth, and burnt in a clamp or a kiln. Including the joints, they may be considered as 9 in. by $4\frac{1}{2}$ in, by 3 in. [**55**]. The plasticity of the clay enables the material to hold together before burning, the sand prevents the excessive hardening and shrinkage which would take place with pure clay, the lime assists in forming a flux producing semi-vitrification, and the iron, magnesia, etc., give the colour to the brick. Clay, or silicate of alumina, is a peculiar plastic material in its natural state, like a tenacious mud, which may be dried and again wetted without altering its properties, but when it is raised to a dull-red heat the chemically-combined water is driven off and the plasticity is permanently lost. This is the principle of the manufacture of *red ballast*, used for bottoming footpaths and for the aggregate in jerry-builders' concrete. It is also the essence of brickmaking, but in this case the burning is carried further, so that incipient vitrification takes place throughout the mass. Bricks may be hand or machine made. Hand-made bricks, again, may be sand moulded or slop moulded.

Brick Clamps. In the neighbourhood of London, where brick-earth abounds near the surface, and where the same site is to be utilised for building upon, it is usual to burn bricks in a clamp. What is called *coke breeze*, but is in reality sifted dustbin refuse, is thoroughly mixed with the brick-earth by passing them together through a pug-mill, and the tempered clay is then pressed into a mould to shape the brick. It is prevented from sticking to the mould by the latter being dipped in, or sprinkled with, dry sand, when the bricks are known as sand moulded; or the mould is dipped into water each time, when the bricks are known as slop moulded. The clamp is a loosely-built structure of 00,000 to 500,000 dried raw bricks, with layers of coke breeze in the lower portion, and live holes and flues formed of burnt bricks. The outside is covered with old underburnt bricks, and the windward side is plastered with clay or protected by corrugated-iron sheets. After the clamp is well alight the combustion spreads throughout the mass, as each brick contains its own fuel, which ensures thorough burning of all except those on the extreme outside. Clamp-burnt bricks are somewhat rough and discoloured in appearance, and often show traces of the coke breeze, but they are, on the whole, sound and cheap.

Brick-kilns. In a permanent brickfield' a kiln or oven is usually constructed for burning the bricks. A plain kiln, known also as a Scotch kiln [**56**], is an open topped brick building, with doorways at the ends and fireholes along the sides, in which the raw bricks are built up somewhat after the manner of clamps; but as they do not contain any breeze all the fuel has to be provided around and beneath the bricks. Kiln-burnt bricks are frequently *brindled*, or marked in light and dark stripes, due to the partial exposure of the surfaces when laid in the kiln, and the greater or less action of the fire upon them. With this exception, kiln-burnt bricks are more uniform in shape and colour than clamp bricks, and there is less waste in the manufacture. There are several varieties of continuous kilns, such as the Hoffmann [**57**], and others. These are arranged in compartments, in which the bricks are in different stages of burning at the same time, so that there is constantly one forward being cleared of the finished bricks and one behind being filled with raw bricks.

Stock Bricks. *Stock bricks* is a term used locally to denote the ordinary brick of the neighbourhood, but it applies more particularly to bricks made in the London district from a brick-earth immediately underlying the vegetable soil. It is rather a coarse brick, but hard and strong, usually of a pale-buff colour, but inclined to red when insufficiently burnt. Coke breeze is mixed with the clay, so that burning takes place throughout the mass, rendering the interior as hard as the outside. When Oxford clay is used, the interior is a dark blue-black colour with a shaly fracture, and sometimes containing lumps of free lime, which render it liable to crack after being built in a wall. A good stock should resist scoring on the surface by a penknife.

Place Bricks, or Grizzles. These are soft, reddish, underburnt bricks from the outside of a clamp, or the top of a kiln, of no use except for filling a brick-nogged partition, as they crumble and powder on exposure to the weather, or in a damp situation.

Chuffs. *Chuffs or shuffs* are bricks full of cracks, but otherwise of hard texture; if well burnt they may be broken up to form the aggregate for concrete.

Washed Bricks. These are made of clay which has been washed to remove the stones. When the stones are left in the clay, they burst in the burning and crack the bricks.

Cutters and Rubbers. These bricks are hand made, of a larger size than ordinary bricks, and with a certain amount of sand in their composition, so that they may cut and rub freely. They are used for gauged arches,

brick aprons, and where any carving of brickwork is required. They should yield to scoring by a knife, but not by the thumb-nail.

Fletton Bricks, or Flitters. This variety comes from around Peterborough, and has been largely used of late years. They vary in colour from red to a dirty grey, and are not equal to London stock bricks, although used as substitutes in common work.

Machine-pressed Bricks. These are of various colours according to the clay used, and owing to their smooth surface are suitable for town buildings, where smoke and soot abound. Being very regular in shape, they may be built with close joints.

Sand-faced Bricks. This variety is preferred by architects, from the good tone and texture and uniform colour, although they do not weather so well. Those should be selected which have a good ring when struck together.

Blue Bricks. Blue bricks are made chiefly in Staffordshire, and owe their colour to the large amount of oxide of iron contained in the clay. They are very thoroughly burnt to obtain a vitreous structure, and hence are very hard and durable. They are used for heavy foundations, plinths, inverts of sewers, and wherever moisture or hard wear have to be resisted. For door and window-jambs in warehouses the angles are generally rounded by using bull-nosed or quoin bricks, with a round corner, bonded in with rectangular bricks. True Staffordshire blue bricks are a deep blue-black colour throughout, but inferior ones have the outside the right colour while the inside is red, being formed of common clay dipped in a wash to colour them in burning.

Paving Clinkers. Paving clinkers are of two chief varieties—the *terro-metallic*, of the same colour and quality as Staffordshire blue bricks; and *adamantine clinkers*, of a pale-buff colour, from Stamford in Lincolnshire. They are machine pressed, and hence very heavy and dense in structure, resisting wear to an astonishing degree, and impervious to moisture.

Glazed Bricks. Glazed bricks are usually dipped in a "slip" of specially prepared clay, so that when burnt a china-like skin of an artificial colour is produced on the exposed surface, either white or any other colour that may be desired. Glazing is also produced by throwing salt into the furnace, hence the term "salt-glazed" which is applied to stoneware pipes similarly treated, but these are not dipped, so that they retain their natural colour.

Firebricks and Clays. Bricks in general are the best fire-resisting materials we have, but some varieties are peculiarly good in this respect, although not having the other properties required in ordinary construction. These are known as firebricks, and may be roughly divided into two classes, according to the material from which they are made—*viz.*, (*a*) the silicate of alumina class, in which the alumina is about half the silica, and the silica is chiefly in the combined form; and (*b*) the siliceous class, in which the silica predominates up to about 90 per cent., chiefly in the free state. Class *a* burn hard, are dense and smooth, and make good paving-bricks. They are only suited for moderate heats. Class *b* are rougher to the feel, are somewhat friable when burnt, have a coarse grain, but are very refractory, withstanding furnace heats up to 4,000 or 5,000 deg. Fahr. Stourbridge bricks are intermediate in character, while Dinas bricks possess the extreme degree of refractoriness. This results from their freedom from iron oxide and alkalies—in fact, a small percentage of lime has to be added in the manufacture as a combining material to hold the grains of silica together.

Terra-cotta. *Terra-cotta*, as the name implies, is burnt earth, or, rather, a mixture of clays that will burn to a dense but not too hard condition, with a smooth, semi-vitrified face. It must be capable of moulding easily—that is, must take the impression well and retain its shape while drying, and not shrink or warp excessively in burning. Terra-cotta for building purposes is moulded into hollow blocks, with shells about 2 in. thick, in order that the drying and burning shall be more uniform. The interiors are filled with fine concrete before the blocks are placed in position in the building. It is most important that the outer skin shall be left intact, as this is virtually imperishable; while the interior, if left exposed, would weather badly. The colour varies from a buff or pink to a dark red, according to the proportion of oxide of iron contained in the clay.

Roofing Tiles. *Roofing tiles* are generally made from red terra-cotta clays squirted in a thin band of the requisite section and wire-cut into the required length. *Pantiles* [**58**] are then baked, but *plain tiles* [**59**] undergo a preliminary pressing in order to consolidate them, and render them more impervious to the weather. Plain tiles are, before burning, bent over a leather saddle to make them hollow on the underside, so that they may fit closely at the tail, to prevent rain from driving in the joint. They are holed for the pegs at the same time.

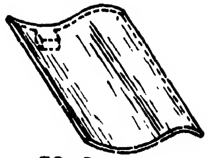
Ridge Tiles. Ridge tiles [**60**] are used to span the ridge of a roof and cover the slates or tiles on each side in order to form a weather-tight joint.

Hip and Valley Tiles. These [**61** and **62**] are made of special shapes, to fit the hips and valleys of tiled roofs, and varied to fit the pitch of roof for which they are required.

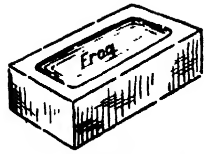
Ornamental Roofing Tiles. Various outlines and sections are made similarly to plain tiles. Common forms are shown in **63**.

Hanging Tiles. These are made of the same material as roofing tiles, unless they are finished with a glazed surface, when they are more often of stoneware, and made to any required colour by a dip-glaze upon the exposed face.

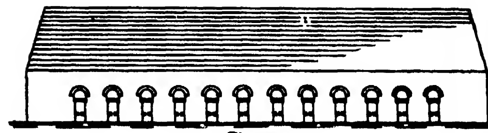
Wall Tiles. These tiles when bedded direct upon the wall, are usually made of stoneware, with dovetailed grooves or holes in the back to form a key, and glazed on the face to any



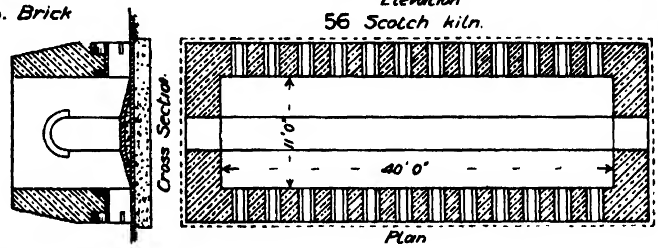
58 *Pantile*

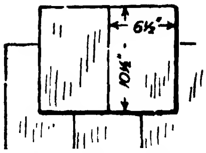


55. *Brick*

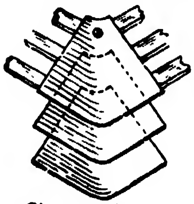


56 *Scotch kiln.*

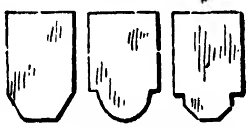




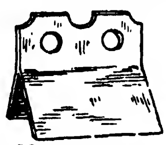
59. *Plain tiles*



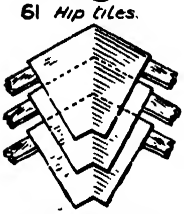
61 *Hip tiles.*



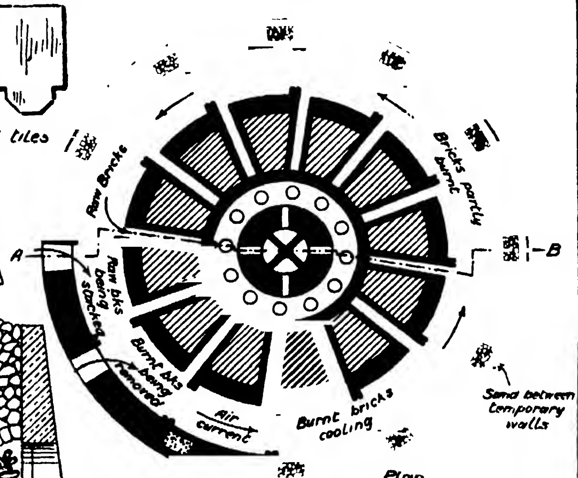
63 *Ornamental tiles*



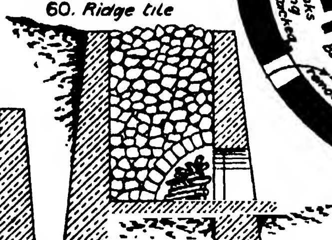
60. *Ridge tile*



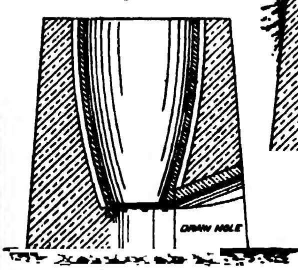
62. *Valley tiles*



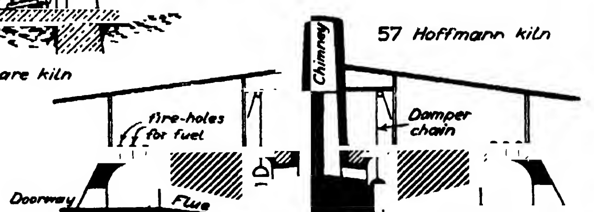
57 *Hoffmann kiln*



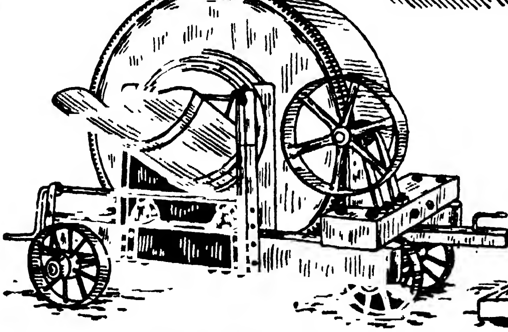
64 *Flare kiln*



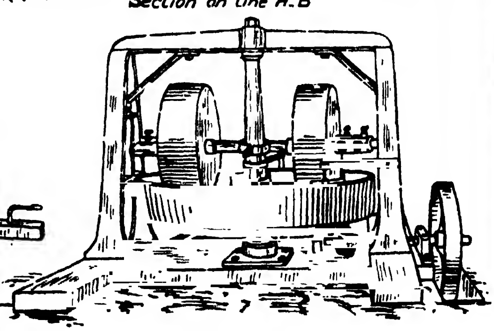
65 *Draw kiln.*



Section on line A.B



67 *Concrete mixer.*



66. *Mortar mill.*

required colour by a dip-glaze, in which they are inserted before burning, and they are then known as glazed tiles.

Embossed Tiles. *Embossed tiles* are pressed in a mould with a sunk die, which makes a raised figure on the surface of the tile, afterwards glazed.

Encaustic Tiles. For *encaustic tiles* the die has a raised pattern, forming on the face of the tile depressions which are filled in with a differently coloured slip. Various modifications are adopted to produce the different patterns and colouring required by architects. Inferior encaustic tiles, in which the colour is merely applied as a transfer on the surface, instead of being burnt in along with the clay, are now largely made. The best encaustic tiles consist of three layers: (*a*) a slab of very pure clay of the colour required for the ground of the pattern; (*b*) the body, which is of coarser clay; and (*c*) the back, which is formed with a thin layer of clay different from the body, to prevent warping.

Dry Tiles. These are, as their name implies, made by a dry process, and are of the same colour throughout. The clay is carefully prepared and mixed with the colouring agent, passed through muslin or silk sieves, dried, and reduced to a fine powder, which is placed in a press and reduced to about a third of its bulk as well as being thoroughly consolidated. At the same time the pattern, if any, is impressed by means of a die. The tiles are then carefully dried in a hot room, glazed and fired.

Majolica Tiles. This variety has various colours applied in the form of an enamel or glaze, and undergoes successive burnings to incorporate all the colours properly. The same process is applied to ornaments and figures, as in the majolica fountain in front of the Bethnal Green Museum.

Glass Tiles. *Glass tiles* were at first simply thick glass with an opal face, and are much cheaper than ordinary white-glazed tiles, but very liable to fracture. They are now made in a great variety of styles and colours and with raised patterns.

Paving Tiles. *Paving tiles*, paving blocks, or quarry tiles, are made of red terra-cotta clay, 6 in. or 12 in. square and 1 in. to 1½ in. thick. They are laid dry on a thin bed of sand, or bedded and jointed in mortar. They are used chiefly for outdoor side-passages of houses, where the traffic would otherwise work up the soil into mud, and for the floors of washhouses, sculleries, and farm kitchens.

Floor Tiles. The commonest are terra-cotta or stoneware tiles, 6 in. square and ½ in. thick, in buff, red or black, used in greenhouses. The better kind are made in various shapes—square, hexagonal, triangular, and rectangular, coloured throughout their substance by colouring matters mixed with the clay before pressing and burning, and used to form *tessellated pavements* or mosaic patterns for halls, passages, &c. When well burnt they are very durable and pleasing in effect. Smaller pieces of the same material are called *tesseræ*. These are made either by the dry process, above described, or out of moist clay cut into various shapes by wires. They are very true in form, and can be laid in mosaic work without any rubbing.

Mosaic Work. Mosaic work is formed by small pieces of tiles or marble bedded in cement. In one method a pattern is made upon brown paper, upon which the pieces are temporarily stuck, face downwards, and the whole is inverted for fixing. In another system they are imbedded direct upon the floor. This is known as *Roman mosaic*. Care has to be taken that the foundation is sound and rigid, and that properly air-slaked cement alone is used, as otherwise unsightly cracks appear upon the finished surface.

Mosaic paving slabs are made by arranging tesseræ to the required pattern in a rough wooden frame. Cement is then run in over the backs of the tesseræ and the whole formed into a slab, which is strengthened by two layers of tiles set in cement.

Drainpipes. It is only within the last fifty years or less that any care has been taken in the manufacture or laying of drainpipes. Soil drains for taking domestic wastes may be made of cast-iron or of stoneware. The former have the advantage of fewer joints and greater strength, but they have the disadvantage of requiring to be carefully protected from corrosion by coating, when hot, with a pitch compound known as Dr. Angus Smith's process. Stoneware pipes, when properly made and used, have the advantage of permanency without further preparation.

Stoneware Pipes. These are made from refractory clays, mixed with sand and ground pottery to prevent shrinkage, and burnt at a high temperature, so that they are vitrified throughout, and are hard, dense, and impervious to moisture. In order to present as little obstruction as possible to the flow of liquid, and to prevent any accumulation of deposit on the inside, they are salt-glazed; but the best kinds have the spigot ends and the insides of the sockets unglazed, so that the cement used for making the joint may hold firmly. They are 2 ft. long from bottom of socket end to the end of spigot, and vary from 3 in. to 15 in. inside diameter. A diameter of 4 in. is sufficient for ordinary house-drains, and 6 in. for a mansion. The larger sizes are sometimes made oval, so that a small flow may take place with the least wetted perimeter, and consequently the least friction. Traps of all kinds are made of the same material. Stoneware pipes should have a yellowish-grey fracture and be incapable of being scored with a knife.

Earthenware Pipes. Common socketed drainpipes are made from mild clays which will not stand a very high temperature in burning, and they are consequently somewhat porous and not so durable as stoneware pipes. As the salt-glaze that is used is nearly transparent earthenware pipes can be detected by their reddish colour. They have also a less metallic ring than the stoneware pipes, and the fractured surface can generally be scored with a knife.

Agricultural Pipes. These are made of similar clays, squirted in a pipe machine and cut off with a wire into short cylindrical lengths. They are made without sockets, and laid with butt joints nearly touching, but leaving sufficient space between for water to enter. They are only used for draining land, or for insertion in a retaining wall as weep-holes.

Flower-pots and **Seed-pans.** These articles are made of the same material as agricultural pipes, on a potter's wheel, and afterwards baked. When made into fancy shapes or into small figures they are called terra-cotta.

Sand. Sand may consist of small grains of any material, but what is commonly known as sand consists almost entirely of small grains of quartz, which is nearly pure silica, as sea sand. Pit sand is coloured by oxide of iron (Fe_3O_4), the colour varying from yellow to red, according to the amount contained. Pit sand is usually contaminated with a certain amount of clay, causing it to have a loamy feel, and this has to be washed out before the sand can be used for mortar or concrete, as the smallest quantity when wetted forms mud, which spreads and envelopes the lime or cement, preventing the adhesion of the mass. For this reason, the finer the lime or cement is ground, the better chance it has of resisting the presence of clay. All sand is formed by attrition of larger particles in the ordinary course of nature, so that the grains are more or less rounded. What is called *sharp sand* is merely sand that is free from clay, and not sharp in the sense of pointed, angular fragments. When examined under the microscope some varieties are more angular than others, but freedom from clay is the essential point. For plastering and for fine joints in gauged work it is necessary to screen or sift the sand to obtain small uniform grains, but for thick joints, especially for use in concrete, sand of varying size is advantageous. Sea sand may be used with Portland cement, as the slight hygroscopic properties are beneficial, but the same properties are detrimental in the case of lime, retarding the setting and causing an efflorescence on the work.

Gravel. *Gravel* is simply large sand. *Ballast* is sand and gravel mixed. *Burnt ballast* is clay burnt to a red colour, as described above. *Hard core* is the material used in the foundation of roads, consisting of brick rubbish, broken slag, furnace clinkers, and frequently dustbin refuse.

Varieties of Lime. *Lime, caustic lime, or quicklime* (CaO) is formed by burning chalk, marble, or any limestone containing a large proportion of carbonate of lime. Its great value in construction lies in the fact that when slaked and mixed with sand to form a mortar it can be used as an adhesive for joining bricks or covering walls, where it sets—in which process it absorbs carbonic acid from the air—and becomes hard again by reversion to carbonate of lime ($CaCO_3$). The calcination is effected in a *flare-kiln* [64] or a *draw-kiln* [65]. The flare-kiln is best for chalk-lime, where the colour requires to be kept pure. It consists generally of a rectangular building with dome top, having fire holes along the bottom over which rough, tunnel-like arches are turned with blocks of stone laid dry, leaving many spaces, and the chalk is piled over these arches so that only the flame passes through the chalk, while the carbonic acid and moisture escape through an opening at the top. Generally, two or more of these kilns are arranged side by side and worked alternately. A simple flare kiln is shown in **64**. The draw-kiln is a common form frequently seen on a hill-side in a chalk district. It is shaped like an inverted cone or parabola, with a draw-hole at the bottom [65]. In this kiln the stone and fuel are tipped in alternate layers, and the burnt limestone is withdrawn from the bottom.

Pure Lime. *Pure lime*, called also *rich*, or *fat lime*, is made from chalk or marble, which are practically pure carbonates of lime. The calcination drives off the carbonic acid and water, leaving pure quicklime. This possesses the property of absorbing a great amount of water with a hissing noise, the evolution of considerable heat, and a great increase of bulk, passing into the form of hydrate of lime, commonly known as slaked, or slacked, lime. It undergoes this change slowly on mere exposure to the air, reabsorbing carbonic acid at the same time. It is called rich, or fat lime, because it will bear a large proportion of sand mixed with it. Pure lime is used for lime-whiting and for plastering. It never attains great hardness, but is very free from *blowing*, because of its readiness in slaking. If any other lime is used for plastering, it is apt to blow—that is, small particles that have resisted the primary slaking, slake in the wall and blow off small patches, or cause blisters. As the setting is so prolonged pure lime is not suited for making mortar for building walls.

When the chalk or limestone is impure a *poor lime* is the result, the impurities forming so much inert matter, reducing to that extent the amount of sand that may be used with it.

The *grey lime*, or *stone lime*, used in the neighbourhood of London is in this sense a poor lime obtained from Dorking, Halling, Merstham, etc. It swells less in slaking, with less evolution of heat, but containing about 4 per cent. of alumina, it sets more rapidly than pure lime. Grey lime is so called from the colour of the stone from which it is produced, the lime itself being yellow.

When the limestone contains clay (silicate of alumina) the lime formed from it sets quicker, and is classed as *feebly hydraulic*, *moderately hydraulic*, or *eminently hydraulic*, according to the amount of clay contained. The term hydraulic means ability to set in a damp situation.

Blue Lias Lime. *Blue lias lime* is burnt from limestone from the lias formation in different districts, as Keynsham, Lyme Regis, Bath, Aberthaw, Rugby, etc. Some of it is only moderately hydraulic, but other samples are eminently so. As in the case of stone lime, the name comes from the colour of the stone and not of the lime, which is generally grey, with a shelly fracture. It slakes sluggishly, and is therefore better when ground in a mortar-mill [66]. For large engineering works the mortar

is usually delivered in the lump and ground with the sand, or often with broken brick. For builders' use the lime is generally delivered ready ground It is the only kind of lime that should be used for lime concrete, but Portland cement is now so cheap that cement concrete should always be used.

Selenitic Lime. *Selenitic lime*, or *selenitic cement*, was introduced by General Scott, and is hence also called *Scott's cement.* It is made from a hydraulic lime, such as blue lias, by adding 5 to 7½ per cent. of sulphate of lime in the form of plaster-of-Paris or other sulphate, or even sulphuric acid, and mixing and grinding them together finely. The slaking is reduced or arrested, the setting expedited, and the strength increased, or a larger proportion of sand may be used if no increase of strength be desired. It is used chiefly for mortar, but also for plastering and concrete.

Cements. *Roman cement* is a natural cement formed by the calcination of nodules found in the London clay at the Isle of Sheppey, Harwich, etc. It is a rich brown colour, very like the pozzolano or trass which it supplanted. It sets very rapidly, and is therefore useful for tide work in repairing dock and sea walls. It is used neat, and even then has little strength, the maximum being attained in about one month. It was formerly used in setting coppers, as it stands fire better than Portland cement. It has, however, practically gone out of use.

Portland Cement. This is an artificial cement of a grey colour, formed by mixing and calcining chalk and clay, or limestone and clay; the former being mixed by the wet process, and the latter by the dry process. In this country the bulk of the cement is manufactured by the wet process on the banks of the Thames and Medway. The proportion of the ingredients depends upon the pureness of the chalk; if it contains clay less having to be added. For example, 80 per cent. of grey chalk is mixed with 20 per cent of clay, but with upper chalk, which is purer, the proportions may be 66 per cent. of chalk to 33 per cent. of clay. The ingredients are mixed in water to the consistence of thick cream, called "slurry," and the fine particles in suspension are allowed to settle in tanks, or backs, for some weeks. The clear water is run off by weirs and sluices, and when the slip is sufficiently solid it is dug out and removed in barrows to the drying floor, and subsequently loaded into the kiln. Intermittent kilns were formerly used, the slurry and coke fuel being packed in alternate layers. Now continuous rotary kilns, gas fired, are being used. The calcined cement is afterwards ground to a fine powder, so fine, in fact, that a residue of only 12 per cent. is left on sifting it through a sieve of 10,000 holes per square inch.

Plaster Cements. *Plaster cements* is a general term applied to those cements used in plastering which depend principally upon plaster-of-Paris as their chief ingredient.

Plaster-of-Paris. This is produced by the gentle calcination of gypsum, which is a brownish, semi-transparent, crystalline, hydrated sulphate of lime, found in the clays round London and Paris. It consists of lime, 26¼ parts: sulphuric acid, 37⅛ parts; water, 17 parts; and when calcined the water of crystallisation is driven off, making it anhydrous. It sets rapidly by the absorption of water, which makes it again a hydrate, and expands slightly in setting. Being soluble, it is not suitable for outdoor work.

Keene's Cement. This is made by recalcining plaster-of-Paris after soaking it in a saturated solution of alum. It sets quickly and hard, and is used for screeds on external angles of inside wall plastering, skirtings, dados, and other parts liable to rough usage. It is not suited for outside work, as it will not withstand the weather. It is made in two qualities, coarse and superfine, and is usually of a pinkish colour.

Parian Cement. This, sometimes called *Keating's cement*, is produced by mixing calcined and powdered gypsum (plaster-of-Paris) with a strong solution of borax, and afterwards recalcining, and grinding. It is said to be mixed with a solution of alum after this, but there is some doubt on the point. It sets very hard, but does not give such sharp angles as Keene's or Martin's cement, although it is preferred to these for large surfaces, as it works more freely. It is not suited for external work owing to its solubility.

Martin's Cement. This cement is made in a similar manner to Parian, but carbonate of potash is used instead of borax.

Stucco. *Stucco* is the common term for all kinds of plastering to be finished with a coat of paint. It is also used for external rendering in cement to imitate stone. The composition of *common stucco* is one part of hydraulic lime or cement to three parts of sand. *Bastard stucco* has a small proportion of hair, two-thirds fine stuff to one-third fine sand, and is chiefly used for surfaces to be painted. *Trowelled stucco* for interior work has a small proportion of plaster-of-Paris. *Rough stucco* has larger sand or small gravel mixed with it. *Rough cast* is the final coat of plaster or rendering to external walls, much used in half-timbered work and on the basement walls of Queen Anne work. The first and second coats of coarse stuff (one lime, three sand) are evenly applied, and, when set, the rough cast is thrown on, consisting of sand, washed and screened gravel or grit, mixed with hot lime to a semi-fluid condition. It may be coloured immediately with lime and ochre, or left in its natural condition. From its mode of application it is sometimes known as *gravel-dash.*

Plastering. The first coat of plaster on laths is called the *pricking-up coat*, and is made of *coarse stuff*, which is a rough mortar containing 1 or 1½ parts of sand to 1 part of slaked lime by measure, thoroughly mixed, with 1 lb. of sound long ox-hair to 2 or 3 cubic ft. of stuff. After this coat is put on it is, while still soft, scored or scratched all over to form a key for the next coat. When this is quite firm, but not too dry, the second, or *floating coat*, consisting of either a repetition of the coarse stuff, or of fine stuff with a little hair, is applied. *Fine stuff* is pure lime slaked with a small quantity

of water, afterwards diluted with more water, and allowed to settle. The water is then run off, and that in the mass allowed to evaporate until the stuff is thick enough for use. Before the floating coat is too dry, it is swept over with a birchbroom, and when quite dry the third, or *setting coat*, is applied, consisting of two-thirds fine stuff and one-third very fine clean sand, with or without hair. *Rendering* is the application of plaster or cement mortar to brickwork.

Scagliola. *Scagliola* is a mixture of plaster-of-Paris with various colouring matters, dissolved in glue or isinglass, to imitate marble, and applied to flat surfaces or to columns. It has a wooden backing covered with coarse Keene's cement, the surface of which is scored in irregular or diagonal lines. To this the second coat is added, and is coloured when moist to represent the marble. When dry it is rubbed over with a hard stone, and afterwards treated with liquid Keene's cement to fill up the pores, and is again polished. The final gloss is obtained by a rag and linseed-oil.

Putty. *Plasterers' putty* consists of pure lime mixed with water, slaked to a creamy consistency and run through a hair sieve. It is then left in a putty-bin until it attains the proper consistency for use.

Gauged Stuff. This, also called *putty-and-plaster*, is made of three to four-fifths plasterers' putty and the remainder plaster-of-Paris. It must be mixed in small quantities as the plaster-of-Paris causes it to set quickly.

Masons' Putty. Masons' Putty is very similar to plasterers' putty, but has white marble dust mixed with it. Another variety is made by mixing lime, white-lead and silver sand.

Glaziers' Putty. This is made of whiting finely powdered and mixed with raw linseed-oil to a stiff paste and left for 12 hours, then kneaded up into small tenacious lumps. For outside work it has sometimes a little white-lead or turps, or boiled linseed-oil, to cause it to set harder. *Whiting* is pure white chalk ground and made up into lumps with water. When putty has got stale and hard it may be worked up again by beating it for some time with a mallet and kneading it with the hands.

Mortar. Good building mortar is composed of 1 part of freshly ground stone-lime to 2 or 2½ parts of clean, sharp pit sand. For ordinary work it is mixed by hand on a wooden platform. The lime having been first measured out, enough water is added to slake it, then covered with the sand, and when thoroughly slaked the whole is incorporated by turning over several times. If large quantities are required the mixing should be done in a mortar-mill [66]. The mortar should be used as stiff as possible, the bricks wetted before laying, and the joints well filled.

Cement Mortar. This consists of 1 part of Portland cement to 3 parts of clean sharp sand. The materials should first be mixed dry on a wooden platform, and then wetted through a rose while being turned over. It should be used within an hour of mixing and before it has begun to set, and in building brickwork the joints should be raked out as the work proceeds.

Mill Mortar. Mill mortar consists of plaster, old bricks, and builders' rubbish, with a dash of lime, ground together in a mortar-mill, and used by speculative builders.

Concrete. *Lime concrete* is composed of ground stone-lime or grey lime and ballast, say 1 to 6, but there is no purpose for which this material should now be used. Even the best has little strength, and it will not set in a damp foundation. If lime concrete must be used, it should be *lias lime concrete*, consisting of, say, 1 part lime to 6 of ballast, but Portland cement is now obtained so cheaply, and is so greatly superior to lime in the manufacture of concrete, that it alone should be used.

Portland Cement Concrete. This has finely ground and properly air-slaked Portland cement as a matrix, and is mixed with sand and larger material as the aggregate. The aggregate should be so proportioned and varied in size that when the mixture is properly made all the interstices are practically filled, and a solid mass results, each particle of the aggregate being enveloped in a coating of cement. For foundations the proportion may be 1 cement, 2 sand, and 6 larger aggregate, varying from ½ in. to 1½ in. diameter, consisting of any hard material; for large contracts a concrete mixer [67] is found economical. For fire-resisting floors great care must be taken in selecting the materials and mixing the concrete. A specification clause would be as follows. "The concrete is to be composed of one part by measure of Portland cement as described, to one part of clean sharp, coarse sand, and four parts of coke breeze, pumicestone, hard brick, clinker or slag, free from dust, broken in various sizes to pass a 1 in. ring as a maximum. The materials to be carefully mixed dry on a wood floor, not more than ½ cubic yard at one time, and again turned over twice while being watered through a rose." All concrete must be used within one hour of mixing, and not disturbed afterwards. Flint gravel or broken limestone is not to be used under any circumstances for fireproof work.

Ferro-concrete. *Ferro-concrete* consists of Portland cement concrete and steel rods used in combination, so that the concrete takes the compression, or thrust, and the steel takes the tension, the amount of each material being inversely proportional to its resistance. It is now used for all varieties of building, and is very economical, but it is essential that the concrete should be made by skilled men under rigid supervision. The cement forms a natural protection to the steel, preventing oxidation, so that it is expected to be very durable, but the system has not been long enough in use to enable any actual estimate of durability to be formed.

Reinforced Concrete. Used as a raft in foundations, this may consist of not less than one-tenth per cent. of steel rods in both directions, laid through the middle of the depth and previously painted with cement wash.

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VARIATION AND EVOLUTION

Causes of Variation. Influence of Environment. Parent and Child. The Main Theories of Evolution Considered. Bathmic, Lamarckian, and Darwinian Views

By Dr. GERALD LEIGHTON

SOME, perhaps a little better acquainted with biological literature, would mean by their question "Do you believe in Darwinism, or the doctrine that living species have originated by a process of natural selection of the fittest in the struggle for existence?"

Here the word evolution is used as a synonym for one particular theory of the origin of species—Darwin's theory. This is almost as inaccurate as the former case. One may be a Darwinian or not—that does not necessarily affect our recognition of the great fact of the existence of evolution. It may be remembered that the late Lord Salisbury, in his Presidential address to the British Association, seemed to throw doubt upon the fact of organic evolution by a disbelief in Darwin's theory of natural selection. Huxley's retort showed how the term was misused. He said, "If all the conceptions promulgated in the 'Origin of Species' which are peculiarly Darwinian were swept away, the theory of the evolution of animals and plants would not be in the slightest degree shaken." Nothing could put the matter more clearly. To use the word evolution when Darwinism only is meant is like making the word Christianity synonymous with the teachings of one sect only. Evolution may include Darwinism, but Darwinism at most is only one aspect of evolution. The greater may include the less; the less can never contain all that the greater involves.

Progress is not "Evolution." One other most common abuse of the word evolution is to be found in the writings of those who restrict the meaning to that of the evolution of living things only. As we have seen, this is "organic evolution"—again only a part of the whole. This mistake is an exceedingly common one in biological literature, and is a relic of the time when "inorganic evolution" was unthought of. There is no longer any excuse for this misuse of the word.

It need hardly now be emphasised that evolution is by no means another word for "progress," though that also is an all too common idea. What we mean by progress depends entirely upon our particular ideal of what life should be. We *hope for* progress, individual and national, but evolution is *inevitable*, a universal principle proceeding in every sphere whether accompanied by what we regard as progress or the reverse.

In a word, the fact of evolution is admitted by all races and creeds; *the methods of evolution* have provided matter for dispute for ages, and still do so. It is our task in this course to learn something of those methods, but it was imperative that we should first realise the full meaning of the fact itself. Moreover, it will be now clearly understood that we are here concerned only with organic evolution, the evolution of plants and animals.

Causes of Variation. We start from the obvious fact that all plants and animals show variation amongst themselves, and change somewhat under different surroundings. That is our common basis; from that we may reasonably hope that a due consideration of evidence will lead us to something in the nature of a common conclusion, making all allowance for individual differences of temperament in the realm of thought. The only real dispute will then be that which is still a somewhat disputed question even amongst those best qualified to judge—namely, the exact method by means of which organic evolution comes about, exactly how it is that living species exhibit the changes which we observe.

Since variation lies at the foundation of all adaptive change, we must first consider what is known as to the causes of variation, concerning which it may be at once stated we are very largely in ignorance. The study of these causes is a comparatively new one, and at present all that can be done is to draw attention to the suggestions that have been made, and the lines upon which the investigation is being carried out.

We have already emphasised the fact that although all living organisms tend to beget offspring like themselves, yet every individual differs in some smaller or greater degree from every other, including its parents, and that this difference constitutes what we term variation. Very remarkable variations we term *monstrosities* or *abnormalities*. It has also been pointed out that variations are *continuous* or *discontinuous*. Looked at in the simplest way, we may say that variations are said to be continuous when they form a gradual series connecting a typical or normal form with an extreme variation. If there are big gaps in the series which have no recognised connection we speak of the departure from the type as a discontinuous variation.

The Laws of Chance. "At present our knowledge of any particular kind of variation is very meagre. . . . But in a few cases a sufficiently large number of observations have been made to enable us to deal with them in a mathematical way, and as far as they point the road to any conclusion it is that they are fortuitous and accord with the 'laws of chance.' Now, events which accord with the laws of chance are simply those which happen under conditions of which we are ignorant. If we toss a penny the chances are equal that the

tail surface of the coin will be uppermost as frequently as the head surface; and we say that in a given throw it is a chance whether the head or the tail will be uppermost. If we knew all the conditions which govern the movements of the penny we could predict of any particular throw which surface would be uppermost, and it would be no longer a matter of chance. But our ignorance of these conditions does not make the throw of the coin anything else than what it is, and our statement that it is governed by the laws of chance does not make the conditions which govern it any different from those laws which control other falling bodies, such as planets, the movements of which we can accurately predict. The laws of chance, therefore, are the same as other natural laws, but they are acting under conditions of which we know little or nothing. The student, therefore, must not be misled by the expression 'laws of chance,' and believe that they are laws independent of, or different from, other laws; they are natural laws acting under conditions of the nature of which we are ignorant." (Mudge.)

Environment and the Germ-cell. We may term such variations fortuitous, or spontaneous, or what we will, remembering all the time that in so doing we simply deny that their origin is known at present, at the same time believing that their origin is governed by some conditions which the future may reveal.

At present the facts of variation seem to be exceedingly disconnected, and no man can say with certainty exactly whither they will lead us. All we can do under such circumstances is to note the indications as far as we can observe them.

Looking for some theoretical explanations for the cause of variation in offspring, the thought naturally occurs that it may be possible that the surroundings or environment of the individual may so affect the whole body that some influence is exerted upon the germ-cells contained in that body. Though the germ-cells are in no real sense produced by the parent (in higher animals), still their vitality depends upon that of the parent being maintained until they themselves become fertilised and started upon their independent career. For a large number of years, perhaps forty or fifty, they are lodged within the parent organism, for care and protection, and for nourishment, and it is no wild suggestion that the condition of the body of the parent must exert some influence upon the germ-cell within. The effect of this may possibly be seen in the production of variations in the offspring.

How does Variation come about? This is by no means the same thing as saying that the environment must produce the same effect in the offspring as it did upon the parent. That would be an entirely different matter. It does not follow, for example, that an alcoholic environment of the parent which caused in him the production of a drunkard will necessarily cause the offspring to exhibit a variation in the direction of drunkenness. But it seems almost impossible that the germ-cell can escape being affected in some way by the abnormal nutrition supplied to it by an alcoholic parent. It may well be that the result of such an environment may be to cause the germ-cell to vary in some way from what it would have been had the parental environment been otherwise.

The variation may be in the direction of insanity or other condition. We know relatively little regarding the nature and extent of variation which may be produced by environmental influences of this kind, but it is difficult to escape the conclusion that there must be some proportion of variations which are to be accounted for by the environment of the parent. We shall have to say something concerning the objections to this view of the causation of variations when we consider the problem of heredity. At present we simply note environment of the parent as one possible explanation.

Causes Within the Germ-cell. It is perfectly plain that if the parental environment is not the cause of variation in offspring, the cause must lie within the germ-cells themselves. Now it is perfectly certain that the parental environment is not responsible for *all* the variations which occur. It is even disputed whether it can account for any of them. Nothing is easier to prove than that all variations cannot be attributed to environment [see HEREDITY later]. Some, at least, arise from causes which act from within the germ-plasm, the laws of which we do not know at present, and for this reason we term these variations *spontaneous*. Spontaneous variations in this connection may be taken to mean all variations which arise independently of any directly immediate action of the environment. "For example, the germ-cells from which a litter of puppies, kittens, or pigs arise are all exposed to practically the same environmental influences, yet the germ-plasms contained in them often differ immensely in hereditary tendencies, as is proved by the great range of variations which may occur among the different members of the same litter." (Reid.)

Sex and Variation. If parental environment were a potent cause of variation, then we should expect all the members of the same litter to vary in the same direction, which they do not. Some of the variations—indeed, some biologists think all, or nearly all—obviously arise independently of the environment—that is to say, from causes which act from the side of the germ-cell, from within. The differences lie in the germ-cells themselves. We have no option but to believe that some variations are thus spontaneous; the question to be determined is whether *any* can be traced to environment. It may be that the processes which are concerned with the maturation and fertilisation of the germ-cells are responsible for some variations, by inducing new molecular arrangements of the germ-plasm which is the basis of inheritance [see PHYSIOLOGY].

It has also been held that the mixing of two more or less dissimilar masses of germ-plasm, such as occurs in the sexual reproductive processes, is a cause of spontaneous variation in offspring. Professor Weismann, the great biologist of Freiburg, and his followers at one time

attributed to this cause all variability, except that in the lowest organisms. On the other hand, Dr. Karl Pearson, Professor of Applied Mathematics, in University College, London, who has given great attention to the mathematical study of variation, denies the influence of this factor *altogether.* "*Variability is not a product of bi-parental inheritance. . . .* Whatever be the *physiological function of sex in evolution, it is* not the production of greater variability."

Parent and Child. The probability is that the truth lies between these two opposing views, and that some variations are the result of sexual reproduction, which, however, cannot be regarded as the sole cause of variability. In what is known as *blended inheritance,* where the characters of the two parents appear to unite so as to cause the production of offspring more or less intermediate between the two, we see a variation obviously due to sexual reproduction. For example, the child of a white man and a black woman as a rule is intermediate in colour and other characters between the two parents. Some variations, then, may be ascribed to this factor, but not all. Variations are not restricted to the offspring produced by sexual means; they occur also in asexual reproduction in abundance, so that there is good reason for believing that some at least of the variations in higher animals which reproduce sexually are due to causes other than the sexual method of reproduction. It will probably be found that the variations due to sexual reproduction are not fortuitous, but in very definite directions, and that if we knew all the characters which made up the parents we could predict with some approach to certainty the kind and amount of variation which could be attributed to the union of their reproductive cells.

To sum up, then, the causes of variation are by no means yet fully understood. The fact itself is seen to be universal in living organisms, and is the basis of all organic evolution. This organic evolution is also a recognised fact; the methods by which it is brought about are to a large extent matters of dispute and opinion.

We are now in a position to turn our attention to the views which have been advanced upon these methods of organic evolution, and to endeavour to take a dispassionate survey of the evidence for and against the different theories. Our view of life itself depends upon the conclusion we reach.

Theories of Organic Evolution. We have already stated that organic evolution has been accepted as a fact by all races and creeds, and that only the methods are in dispute. At first sight this may appear a strange statement, but a moment's consideration will convince that it is true. It is still denied by some that all the species of plants and animals sprang from one common origin. But all men, even the savage races, have some kind of belief in the origin of mankind from a common stock. They may believe that in the far distant past man arose from their heathen gods. Others derive mankind from Adam and Eve or from some lower species of animal. The exact belief matters not. In any case there is admitted or implied a belief in organic evolution, because at the present day mankind is found to differ vastly in his different races—some nations being big, others small; some white, others black or red or yellow; some having straight hair, others having hair short and woolly; each being adapted to special surroundings. It is not possible for a sane human being to doubt the existence of organic evolution. "In particular, it is not possible for the orthodox Christian, who derives the human race from Adam and Eve, to doubt it. Such a one must admit also that evolution may be very rapid, since, according to him, six or seven thousand years only have sufficed to produce types so widely divergent as the Scandinavian and the African pigmy." (Reid.)

The whole problem of organic evolution is the answer to the question—*By what methods have these changes come about?* Three views at least require mention.

Evolution by Miracle: The Bathmic Theory. We need not devote much space to this view, which supposes organic evolution to occur under the direction of a Deity who works by ever-recurring miracles. Very few educated persons now hold it. It is not a question whether an all-powerful Creator *could* bring about organic evolution in this way or not; it is a question of whether this has been the method adopted.

There is, it seems to us, a far grander faith than that in evolution by miracle, using the word miracle in the sense of the supernatural. It is surely better to search for an explanation of natural phenomena in natural laws (God's laws) than in exceptions to those laws, which miracles are. "Only when a natural explanation has been proved to be impossible have we an excuse for a direct appeal to the supernatural." (Reid.)

"Of course the theory of Bathmic evolution may be enunciated in vague terms. God and miracle need not be mentioned. We may be told that species undergo evolution, and so adapt themselves to the changing conditions of existence, not by the action of natural selection, nor by the transmission of requirements, but simply through the operation of an inherent adaptive 'growth force.' Nevertheless, the appeal to miracle is still necessary. No doubt the universal existence of variations demonstrates the existence of a growth, or, rather, change force. But the difficulty which has to be surmounted by the Bathmic evolutionist arises, not from existence of specific or racial change, but from the fact that this change—*i.e.*, evolution—has led, since the beginning of life, to the close adaptation of every race of animals and plants to its own successive environments. Either the environment has acted on species, which have reacted to it, or their adaptive changes were miraculous. There is no third alternative." (Reid.)

We see around us species which under our own eyes are changing in response to surroundings, and we have absolutely no reason

to think that the operations of Nature in the past were different in principle from what they are at present. We see species and varieties connected with each other by subtle links suggesting a common origin. The idea of the special creation of all these connecting links is unthinkable in view of the facts of life. Why all the connections, if every species were created as such? "Why are animals that live a wholly terrestrial life possessed of organs of respiration and associated structures of a purely aquatic nature? Why is it that man, in the course of his embryological stages, passes through conditions that characterise stages and permanent and finished structures of the lower vertebrata? These are difficult questions, very hard to answer, and cannot to-day be answered with certainty or finality. But this much is certain—the hypothesis of special creation does not answer them." (Mudge.)

The Bathmic theory may therefore be dismissed, and we must turn our attention elsewhere for a more reasonable explanation of the facts.

Evolution by Transmission: The Lamarckian Theory. Ever since the time of Aristotle naturalists have been searching for some explanation of organic evolution other than the paralysing dogma already considered. Foremost amongst those in order of time must be placed the eminent French zoologist Lamarck, who, in the year 1801, gave utterance to the view that all existing species have descended from pre-existing species. He did not stop there, but also enunciated a theory which attempted to explain *how* this had come about. It was not until Charles Darwin and Alfred Russel Wallace propounded their views, however, that Lamarck's theory attracted general attention. The two views are contradictory, and hence the one attracted attention to the other. Buffon, another French naturalist, also gave support to the view of Lamarck, and, indeed, Darwin himself attached some importance to some of Lamarck's arguments.

The theory of Lamarck hinges upon the question of the inheritance of acquired characters. According to him, the origin of species results from the acquired characters of the parents being capable of transmission to the offspring. His theory also involves the view that the environment of an animal can directly bring about acquired characters, which are transmissible. It asserts that living creatures are, to a great extent, modified by the kind of life they lead, that these modifications are handed on to their offspring by heredity, and that the modifications accumulate and become perfected in succeeding generations. Nature is supposed to mould creatures to their surroundings.

Heredity in Evolution. The theory has been admirably summarised by Dr. Archdall Reid in "The Principles of Heredity," from which we may quote this passage:

"If we believe with Lamarck that acquirements are transmissible, we find ourselves committed at once to a theory of evolution. In the face of common experience, we need not believe that acquirements tend to be transmitted in their entirety—that a dog which has lost its tail tends to have tailless puppies, or that a man who has attained great mental acquirements tends to have children endowed at birth with *all* that he achieved with pain and toil. But we are committed to the doctrine that the dog's loss and the man's gain will be inherited to *some* extent, however slight, and that, if many successive generations of dogs and men make similar acquirements, the race of dogs will ultimately become tailless, and that of men highly endowed mentally. In brief, the Lamarckian supposes that the effects of everything that benefits or injures the individual, including the effects of all use and disuse, are, to some extent, transmitted to offspring, and that evolution or degeneration results from the accumulation of these transmitted effects during generations. It supposes, for example, that . . . the descendant of many generations of blacksmiths will be stronger physically, but weaker mentally, than the descendants of many generations of students. It supposes that the conditions which produce health and strength in a succession of parents—absence of disease agencies, sufficient exercise, abundance of suitable food and fresh air, the right degree of moisture and temperature, and so forth—will ultimately render the race strong, hardy, and vigorous, whereas contrary conditions will render it feeble."

Limits of the Lamarckian Theory. "It is necessary to note a few additional points: (*a*) Just as the doctrine of the transmission of acquirements is not adequate to explain all the facts of heredity, so, also, it is not adequate to explain all the facts of evolution; for example, while it is perhaps competent to explain man's intellectual powers or the antelope's speed, it cannot explain why man has long hair on his face, which is lacking in woman, or why the colours of one species of antelope differ from those of another. Neither man nor antelopes make acquirements with respect to hair or colour, except such as lead to the loss of them. It cannot explain the differences in the integuments of the different species of fish. It can hardly explain a single fact in the whole world of plants. In fact, however simple and fascinating the Lamarckian doctrine may appear at first sight, however well it may seem to explain certain phenomena, it is quite insufficient to explain the totality of phenomena. It may possibly be accepted as a partial explanation of evolution; it cannot be accepted as a complete explanation. (*b*) Again, it must be noted that the Lamarckian hypothesis . . . supposes that all beneficial agencies which act on a species are causes of evolution, whereas all injurious agencies are causes of degeneration. In this, as we shall see presently, it is in violent and fundamental opposition to the Darwinian view."

The above summary from a work which should be carefully studied by all students of organic evolution will serve to make clear the theory of Lamarck. It will be still more appreciated when we have considered Darwin's view.

Continued

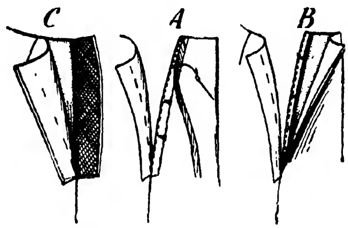
Group 9
DRESS
5
Continued from page 527

THE MAKING OF A SKIRT

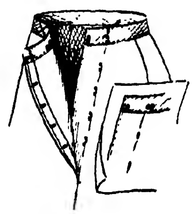
Darts. Fastenings. The Pocket. The Waistband. Finishing a Skirt. How to Evolve Fashionable Skirts from Simple Drafting

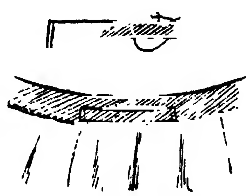
By AZELINE LEWIS

The Darts. Before stitching up the darts, it is well to put on the skirt, to see that they are in their right position, and set well at the waist. If correct, tack them from the top to *about 3½ in.* down, graduating them off to a nice point, so as to avoid any bulging out at the bottom. To do this, when the darts are machined, cut off the threads, leaving fairly long ends; thread one of these, and fasten off the tip of the dart with two or three stitches of oversewing. Now cut down the centre, press open, and fell the lining over.

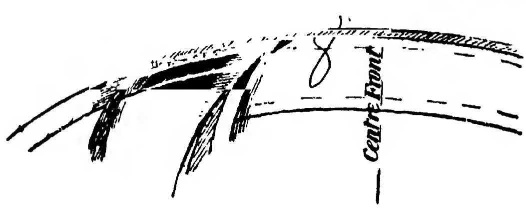


59. PLACKET-HOLE


60. PLACKET-HOLE FASTENINGS


61. THE HANGERS

Preparation for Placket. For the front side gore fold a piece of tailors' linen 1 in. wide, place the fold on the white cotton outline of the placket, holding the linen rather tightly, and slightly easing the bias side to this. Turn down and tack. When this is done the edge should be in a direct line with the seam; then machine ¼ in. from the edge. Catch the raw edge down to the lining, being careful not to take the stitches through. Press before putting on the fastenings. [59*A*]



63. BRAIDING AND FACING

62. FACING FOR FOOT PART OF SKIRT

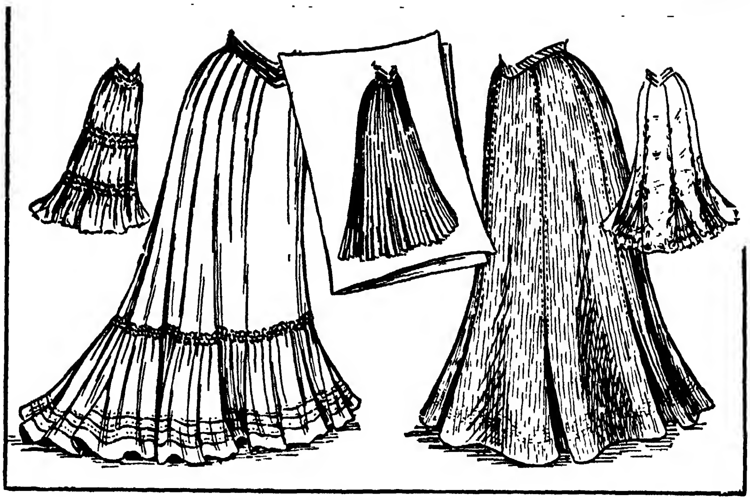
Another way of preparing the left side of front for the fastenings is shown at *B* in the same diagram. In this the fold of lining is placed to the outline of material, the edge of which is then folded over it, tacked and stitched, and the fastenings sewn on. The lining edge is then turned in and felled over them. This method is sometimes advisable in the case of fairly thick materials, and in this case the binding is not necessary; but great care should be taken not to stretch the crossway edge.

For the side gore, take a strip of tailors' linen, 2½ in. wide, and tack between the lining and material. Place one edge of the linen to the edge of the wrap, and the other about ¼ in. beyond placket outline; tack with white cotton along the outline of the placket, taking the stitches right through the linen and material, this last being a guide for putting on the fastenings. If the edges are selvedges, they can simply be stitched without turning in; if raw edges, turn in, tack, and then fell down the long edge and the bottom of the wrap. Take out the tackings and well press. [59*C*]

The Fastenings. The fastenings employed may be socket or spring fasteners, hooks and bars, hooks and loops, either small spring ones or the ordinary kind. Most people prefer the small spring hooks and silk loops, as being neater and more invisible than either of the others.

The socket, or spring fasteners are of two kinds—the one placed on a narrow band of webbing, the other being loose and sewn on singly. The former are recommended, as they are simply felled on the opening of the wrap, care being taken that the fasteners are opposite each other. If hooks and bars are used, the long edge of the bar is sewn on the placket outline of the wrap, the eyes of the bar

being placed towards the edge and buttonholed with silk, to make neat. [60] The hooks are sewn on the bias side, ½ in. in from the edge, and should be faced with galoon or Prussian binding. [59 and 60] If loops be preferred, they should be small, strong ones of silk twist.



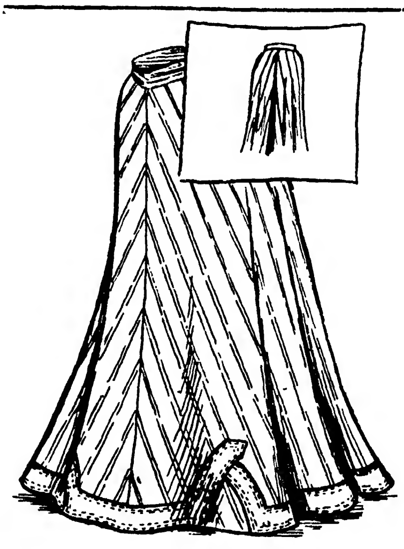
66. SOME POPULAR SKIRTS

The Pocket. The shape of the pocket is shown in diagram 49 [see page 525]. Two selvedges of material and two of lining are required for the opening side, to avoid raw edges, and also to neaten and strengthen the pocket. To draft it, mark 1 to 2, 2 in. down from the waist; 2 to 3—the opening, or mouth of pocket—is 6 in.; 3 to 4—depth of pocket—6 in.; 4 to 5, 7 in.; the line 3, 6 in., or more if required; 1 to 7, 2½ in. Curve from 7 to within 1 in. of bottom (*i.e.*, 5), and curve off from here to line 4.

Outline the opening on both sides with white cotton as a guide to putting in. If placed at a gore, or where the opening is likely to show, this will need to be faced with a strip of the material 2 in. wide, selvedges being placed to those of opening.

To make the pocket, lay the two right sides together, tack the edges, and stitch. Turn inside out, and again tack and stitch all round. Mark 2 in. from the waist; chalk 6 in. down for the pocket opening. Now cut the required opening in the wrap, insert the pocket, stitch in place, and press well.

Putting on the Waistband. The skirt should be put into the waistband before turning up the hem. In the case of a circular skirt, it is best to finish this off entirely at the band and upper part, and then let it hang on a stand for a day or two, if possible, before turning up the foot part. The reason for this is that a circular skirt, being cut mostly on the cross, is apt to "sag," or drop a good deal, especially at the sides; and if it is left to its own reflections on a stand, it will probably decide to do most of its sagging there and then, and so a good deal of the after unevenness may be avoided.



64. A TWO-PIECE SKIRT

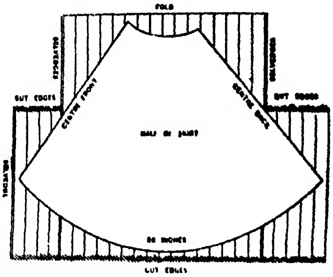
For putting on the band, straight or curved double webbing, single petersham, or satin-faced belting may be used. There is much to be said in favour of the curved double webbing, as it follows the contour of the waist more correctly than the straight; but it must be interlined with linen to give firmness and to take the strain of the hooks and eyes or bars.

Cut the webbing 3 in. longer than the actual waist measure, turn in ½ in. on the right side; run a white cotton at the size of the waist, which will leave 2½ in. for the wrap and for turning in at the other end. Mark the webbing into equal parts, quarter of half-waist measure in each—*i.e.*, 3 in. for 24 in. waist; pin the white cotton on the webbing to come in a direct line with the outline thread of the wrap, then pin the other measurements, one at each seam, and also on the darts; tack and stitch.

The first bar, or eye, is sewn on the part marked F [50] at top of wrap, the corresponding hook being sewn ⅛ in. from C [49]. Care must be taken that the hooks and eyes are exactly in the right places. Another bar or eye is sewn at the extreme end of the placket wrap. For the second hook chalk 2 in. away from the first hook, and the bill of the second must be exactly on this chalk

mark. The hooks and bars should be buttonholed over with silk to be neat. When single webbing is used, the turnings must be neatened with galoon or Prussian binding.

To put on the Hangers. Take 4 in. of Prussian binding for each "hanger," or loop, turn in the ends ¼ in., oversew the edges together, and sew one on each half of the band—inside, of course—stitching them on at the extreme end, and again ¼ in. away. [61]



65. ARRANGEMENT OF STRIPED MATERIAL

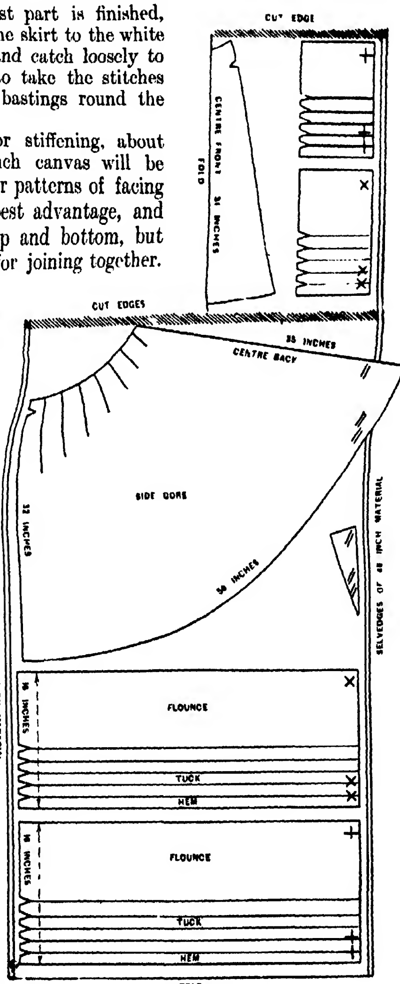
The Bottom of the Skirt. When the waist part is finished, turn up the bottom of the skirt to the white cotton on the lining, and catch loosely to this, being careful not to take the stitches through. Remove the bastings round the bottom only and press.

For the interlining or stiffening, about 1 yd. of very fine French canvas will be required. Lay the paper patterns of facing on the canvas to the best advantage, and cut without turnings top and bottom, but leave ¼ in. at each end for joining together. Trace the centre line on both canvas and lining, and number each piece of canvas the same as the pattern.

The facing must be cut with turnings all round, the fold being placed to the fold of the lining, the edge of side and back-gore portions being placed to the selvedge of the lining.

Now join the facing, open and press the seams. Tack the pieces of canvas together quite flat—*i e.*, place the ¼ in. turnings to overlap each other, to prevent a lumpy seam. Tack facing to canvas along the centre, then turn down the edges top and bottom, keeping the facing quite smooth, and tack along. Now machine top and bottom with a loose stitch ¼ in. from the edge. [62]

The Binding. The protection for the skirt edge will now be put on, which may be braid, brush binding, or one of the many varieties sold for the purpose. We have found brush binding by far the most satisfactory in wear, and also very easy to put on.



67. CUTTING OUT FLOUNCED SKIRT

If braid be used, let this be a good make, as a cheap one wears out almost directly. Before putting it on, soak it in cold water, and then hang out on a line to dry, without wringing it at all. When ready, tack the edges of the braid together, and fell on the skirt, allowing the fold to come ⅛ in. below the edge. Then tack the facing in position over the edge of the braid, placing the fold on the fold of front; pin in position on side gores, also midway between, then baste on the table top and bottom. If a deeper facing be required, it should be tacked three times. Fell the facing to the lining with a fine needle and cotton, then take out the tackings and press, placing a piece of lining on the facing to prevent marking, but on no account use water. [63]

Unlined Skirts. When pleated or full skirts are the mode, they are not always lined throughout. *In this case, however, the fronts should be lined, to prevent the ugly bulging or stretching out at the knee-part, which results when there is no lining to take the strain here.* This latter is a method indulged in by many good tailors and dressmakers. An unlined skirt is faced up at the bottom with lining cut to shape, arranged as already described, but *without* the canvas interlining.

In the case of thin materials, the foundation would be made separately, and secured or not to the waist, as preferred.

Fashion in Skirts. Fashion changes so frequently with regard to the cut of skirts that we cannot attempt to describe the many varieties introduced so frequently to our notice. Sometimes the sheath-like style may be the mode, at others the skirt may be required to fall in voluminous folds

from the waist to the feet. The width, too, may vary from $3\frac{1}{2}$ yards at the foot part (a good average for a walking skirt) to 5 and 6 yards, and even more. We hope, however, that the reader will have grasped from the foregoing examples how easy it is to add fulness at the back for an inverted pleat, and a flare to the sides of the gores of three or more inches; to narrow the front width, or to pleat this as required; to make the whole skirt wider and fuller; in short, to cope with the many variations of the prevailing mode.

So far, we have dealt with a one-piece or circular skirt, also a three, five, and seven gored affair, and shown how to obtain these; but skirts may be cut with any number of gores, up to eleven, this last, however, being better suited to a stout than to a slender figure.

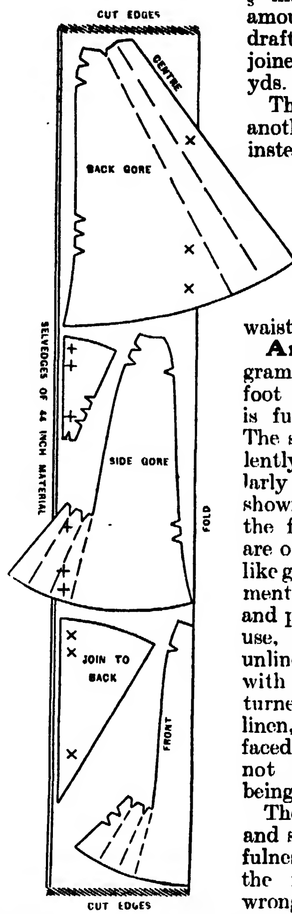
The four-gored shape is a very nice one for a walking skirt, and is practically the same as the five-gored, the difference being that the centre-back is placed to the fold, instead of having a seam here.

With respect to the gores, it may be said that, as a rule, when the number is even — from four upwards—the centre-back and front are placed to the fold.

Some other Skirts. In a two-piece skirt there is a seam at centre-back and front, as seen in diagrams **64** and **65**, which shows a very smart way of arranging this on striped material. For this, however, very great care must be paid to the matching of the stripes, and to the danger of stretching the seams when making up.

Diagram **66** introduces three more skirts. The first has a deep gathered flounce; the second inverted pleats at the foot part; whilst the centre sketch shows a sun-ray skirt.

The shape and method of cutting out the first are shown in the next diagram [67]. From this it will be seen that our drafting can be utilised, the upper part being a three-piece affair, cut, as we have already shown, to the length required to allow for the flounce, the extra width being obtained by separating the gores further at the lower edge. For the tucks in the flounce, 4 in. are allowed—*i.e.*, 1 in. for each—which will give a $\frac{1}{2}$-in. tuck. One inch is allowed for the hem, and the remainder is for the heading. This flounce is cut on the straight, as this will not stretch or drop like a crossway affair, and, of course, may be of any width desired. The upper part is tucked at the waist instead of being fitted with darts; for each tuck about $\frac{3}{8}$ in. should be allowed, and this amount can be easily added to the drafting. Pieces will have to be joined on to the foot part, and $5\frac{1}{4}$ yds. of 44-in. material are required.



68. SKIRT WITH PLEATS

The small sketch on the left shows another arrangement, by gathering instead of tucking, a style which may be recommended only to a tall, slender figure. This skirt, as well as the sun-ray one, is made up without a lining, and both are worn over a separate foundation, which may be secured to it at the waist, or not, as preferred.

An Evening Skirt. In diagram **68** we have an addition to the foot part of a five-gore skirt, which is further cut with a slight flare. The seven-gore variety is also excellently adapted to this style, particularly if used for the evening skirt shown in the smaller sketch, where the fan-like additions to the seams are of net, chiffon, lace, or any such like goods, whilst embroidery or passementerie further decorates the seams and panels. This skirt, for everyday use, may be lined or not; but if unlined, the front breadth is better with a lining, the foot part being turned up over a crossway strip of linen, or horsehair cloth, and then faced with lining cut to shape, but not interlined with canvas, before being machine stitched.

The seams are oversewn, opened and stitched on either side, the lower fulness being tacked down flat in the form of a box-pleat on the wrong side, then secured to the seam and neatened with binding, care being taken to keep the sides straight and to see that they do not drop below the level of the skirt-edge. Four yards of 44-in. material should make this skirt for a medium figure, whilst 9 yards of silk would be needed for the evening skirt, if made with a slight train, which addition is easily made.

Continued

MACHINERY OF THE OFFICE

Legal Aspect of Discount—continued. Divisions of a Business Office. Show-room and Counting-house. Salesmen and Clerks

By A. J. WINDUS

The Benefit of Prompt Payment. It comes to this, then, that not only has X received from C cheque, value £97 10s., but he has also received the benefit of prompt payment, and we know from what has gone before that he places a monetary value of £2 10s. upon such benefit. X, therefore, has received a total of £100—namely, £97 10s. by way of cash, and £2 10s., being the value he attaches to the prompt payment of C's debt. Having already, by rule (*a*), charged X with £97 10s. for cash received, we have now to charge him, under the same rule, with discount £2 10s., representing the value of what else he received—namely, prompt payment. This completes our record of the transaction in the books of C.

The incident we have been studying will also furnish food for thought to the student of Law. In our introductory chapter we made mention of the relations subsisting between Commerce and the Law, and it is most interesting to trace their connection in a given case. We cannot, in our course of study, give prominence to the legal aspect of commercial transactions, but perhaps a few remarks inspired by the foregoing illustration may help to dispel the illusion that Law is a dry subject, and may induce readers to turn their attention to the section which treats of it.

Two Parties in a Transaction. A business transaction presupposes two parties. When money is deposited in a bank, the two parties are the *depositor* and the *banker*. When a shipowner insures his ship with an insurance company, the two parties are known as the *insured*—that is, the shipowner—and the *underwriter* respectively. Similarly, the two parties to the sale of goods for £100 are X, the seller, and C, the buyer. Now, the depositor lodged money at the bank, the insurance company insured the shipowner against the loss of his ship, and X sold goods to C on certain conditions and for a named consideration. The term *consideration* is a legal one and rather difficult to define in few words. Pending our further investigation of it in the Law section [see LAW], let us content ourselves with a partial definition and call it a direct or indirect benefit conferred by one of the parties to a contract upon the other. In the first case just now cited the consideration was the interest allowed by the banker; in the second it was the premium paid by the shipowner; and in the third it was the price of the goods.

In all three cases consideration is present, and the terms on which the business is carried through are understood and assented to by the parties on both sides. Whenever these two elements, (*a*) consideration, (*b*) agreement to terms, are found in a transaction, there is said to be an *Agreement* or *Contract* between the parties. Generally, agreements are reduced to writing—or they may be partly written and partly printed—their precise form being the outcome of the combined effect of law and custom.

Commerce Abounds in Contracts. From the legal point of view, nearly all the more important documents met with in commerce may be described as contracts of one sort or another. Thus a *bill of lading*, besides serving as an acknowledgment of the receipt of goods on board ship, also constitutes a contract between shipowner and shipper for carriage of the goods on the terms named in the bill of lading. In like manner, an *invoice*—formerly called *bill of parcels*—frequently does duty as the contract between the buyer and the seller. All mercantile contracts are founded upon proposals or offers which have been accepted, but for a fuller explanation of the legal doctrine on this point consult the section on Law. [See LAW.] Applying the rule to X, we gather that his invoice for £100, dated March 31st, and giving short particulars of the goods sold, was based upon a prior offer of those goods to C and C's acceptance of such offer. In this way an agreement between X and C sprang into existence, the consideration for which was mutual. X was to supply certain goods and C was to pay £100 for them, and neither party could lawfully break the contract without the consent of the other. Suppose, however, X had promised to deliver the goods to C gratis, could C compel him to do so, the transaction being in all other respects the same as before? He could not, for the reason that X received no consideration for his promise, whereas English law requires consideration for every contract not under seal.

The Legal Aspect of Discount. Let us now apply this reasoning to the case where, X having agreed with C to supply goods for £100, C asked X to take £75 in full discharge, and X promises to do so. C thereupon sends a cheque for £75 to X, which X receives, and then sues C for £25, the balance of the original debt. Can he recover? He may do so, because his promise to take a smaller sum in payment of a larger is, in the eye of the law, a new contract for which he has received no consideration. The lawyers could doubtless explain the justice of such a decision to their own satisfaction.

It is very different, however, with the £2 10s. discount which X has allowed C to deduct. Undoubtedly, there is a second contract in this

case also, which to some extent overrides the first. C agreed to pay X £100, but now X offers, and C accepts, 2½% discount for payment within ten days from date of invoice. This constitutes a new agreement between them, and it is perfectly valid, because X receives consideration for his surrender of £2 10s.—namely, the benefit of prompt payment. Here for the pres nt we take our leave of X.

OFFICE AND STAFF

Hugh Miller, the famous geologist, was employed at one time in a bank. Concerning this experience, he afterwards affirmed that he was handicapped by his inability to trace the bearing of isolated details on the system of which they formed a part. "I could do literally nothing," he wrote, "until I had got hold of the system." The useful hint here given may be pursued to our own advantage. Let us commence with a comprehensive survey of Bevan & Kirk's business, and then, contracting our horizon by degrees, go on to examine with the necessary care all the matters that may come under our notice upon a nearer inspection. The firm of Bevan & Kirk is one but recently established. It was founded at the beginning of the present century for the purpose of carrying on the business of merchants and manufacturers' agents in the City of London—the metropolis of the world. At a later stage, and also in the sections on banking and commercial geography, reference will be made to the immense and preponderating influence which London enjoys in virtue of its position as the geographical, political, monetary, and commercial centre of the world, and then we shall perhaps learn what are the advantages which Bevan & Kirk may derive from the fact of being located in London. Meantime, we note that the firm conducts a shipping as well as a domestic trade. Their business address is 500, Wood Street, London, E.C. The letters "E.C." are an abbreviation for "East Central," showing the postal district of London in which Wood Street is situated.

Definition of a Merchant. The term was formerly restricted to those engaged in the importing and exporting of goods on their own account, but the modern interpretation gives it a far wider meaning. In general, it serves to distinguish a wholesale business of any sort—even though retail and agency transactions are mixed up with it—from a purely retail business. Thus, a firm of colliery owners who sell coal by the hundredweight might describe themselves as coal merchants, on the ground that they supply coal by the hundred thousand tons to steamship companies and others; but for a small greengrocer who obtains his daily stock of vegetables from the Borough Market to call himself a potato "merchant" is a palpable misuse of the term.

Messrs Bevan & Kirk, then, are merchants in a wholesale line of business, but they are manufacturers' agents as well. An illustration will best explain the meaning of the latter term.

The Function of a Manufacturers' Agent. The Berlin Manufacturing Company (headquarters in Berlin) are engaged in the manufacture for export of ladies' blouses and costumes. Now, it is the great ambition of all foreign exporters of manufactured goods, whether French, German, or American, or whatever their nationality, to find an entrance into the most profitable and desirable of all foreign markets—namely, Great Britain. The Berlin Company are, therefore, naturally anxious to introduce their goods into this country, but until they have thoroughly gauged the vagaries of British feminine taste in blouses and costumes they do not wish to incur the expense of a London office and manager, and possibly two or three travellers. The Company accordingly arrange for Messrs. Bevan & Kirk to act as their agents or representatives for the sale of their goods in this country. The agreement drawn up between the parties would contain provisions stating the mode of securing and executing orders, how goods sold are to be paid for, the amount due to Bevan & Kirk for their services as agents, and so on, and we shall consider these matters in their due place.

From what has been said we have an inkling of the nature of the *articles of trade* dealt in by Bevan & Kirk, and we may now add to our list the following: Silks, laces, trimmings, ostrich feathers, boas, fans, lace handkerchiefs, collarettes.

In any business such as this there are two main divisions or departments, known as the warehouse (or show-room) and the counting-house respectively. Occupying a middle position, and related in some sense to both departments, is the entering-desk.

Show-room and Counting-house. Everything that has to do with the actual buying and selling, receipt and despatch, unpacking and repacking, placing in stock and taking out of stock of the goods themselves, is regarded as belonging to the show-room, or *productive* side of the business. On the other hand, everything that has to do with the receipt and payment of money, and the bulk of the work of registering or recording business operations or transactions, is looked upon as belonging to the counting-house, or *unproductive* side of the business.

Salesmen and Clerks. Here we are brought face to face with perhaps the most "pestilent heresy" the clerk will ever be called upon to do battle with in the business arena. Shortly stated, the doctrine is this: A salesman is worth his salt, a clerk is not. Let no one underrate the malignant character of such false teaching. In too many instances the practical effect is that the clerk's salary is grudgingly paid, and is far below that of his fellow-worker, the salesman. Well-known business houses might be named in which boys who started on level terms as counting-house juniors 10, 12, 15 years ago are to-day filling positions, some as salesmen and others as clerks, still in the same establishments, but whereas the maximum scale of salaries for clerks is under £200 per annum, their quondam

companions of the counting-house are drawing hundreds yearly for their more valued services as salesmen. How to combat this undoubted evil must be a point reserved for future consideration; but should any reader have the opportunity of choosing between the position of salesman and that of clerk, he would be wise not to reject the former, except after due deliberation.

But we must hasten on to explain the duties and positions of the various members of the *staff* of Bevan & Kirk, after which we shall treat of the different books of record used both in the show-room and the counting-house. We shall then deal in a comprehensive manner with the firm's system of bookkeeping, and finally we shall exhibit a few specimens of the business forms in use by the firm, such as *invoice*, *statement*, *certificate of origin*, *receipt for goods*, *receipt for cash*, etc. Afterwards we may turn our attention to the import and export trade, and this, we trust, will be found not the least interesting portion of our subject.

The staff of Bevan & Kirk is thus arranged.

Show-room or Warehouse:

2 town travellers, who also act as indoor salesmen, and attend to the execution of orders received.

1 stockkeeper, whose business is to look after the stock, advise his principals when a "line" is running short, assist in the show-room when the travellers are out, and otherwise qualify himself to become a buyer or a salesman.

3 girls, engaged on pattern cards and samples for travellers, and in labelling goods, packing them in cardboard boxes, and so forth.

2 strong messenger boys, who do rough work and act as porters, and who, by assisting or "understudying" the stockkeeper, may learn how to fill his position when a vacancy arises in the firm or elsewhere.

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Counting-house:

The accountant and the junior clerk.

The cashier's duties are performed by Mr. Kirk, the junior partner, who signs all cheques and attends to the financial side of the business.

Correspondence clerk: young lady shorthand writer and typist.

The staff accordingly comprises eleven employees in all. Everyone but the accountant and correspondent (who receive their monthly salaries by cheque) is paid weekly.

Entering-desk. The business is not of sufficient size to warrant the employment of clerks specially for the entering-desk—that is to say, for the work of entering in the *day-book* and on *invoice forms* particulars of the orders executed. This work is therefore distributed among selected members of the staff.

The common routine of the entering-desk in bigger concerns may, however, be described. One clerk takes the day-book, another a batch of invoice forms, and there is a third person who calls off the goods for entry. The caller "gives down" the customer's name, address (but this is sometimes omitted), shipping marks (if any), customer's order number, salesman's number, quantities, weights, or measurements, with the descriptions and prices of the goods and any trade discounts allowed. These particulars are "taken down" by the invoice clerk and the day-book clerk simultaneously. The extensions are made as they go along. Thus, the caller might say, "$50\frac{5}{8}$ yds. No. 48 trimming at 1s.," and this would be extended at £2 10s. $4\frac{1}{2}$d. both in the day-book and on the invoice while he was preparing to give down the next line. So expert do the clerks become in making the extensions of the various items and the castings of the different invoices that within a very few minutes after the caller has ceased calling they have finished their calculations. Of course, the clerks compare notes on the correctness of each invoice total, and when they agree on any total it is assumed that the details which go to make up that total are correct. Comparison of totals is sometimes carried on concurrently with the other work, and then differences can be easily located and adjusted which, if left over until all the calling has been done, might become a source of trouble.

A Bad School for BookKeeping. Regret that this time-honoured method of "entering" is being superseded by the introduction of labour-saving devices, such as the book-typewriter, should be tempered by the reflection that the entering-desk is not a good school of penmanship, and that the old-style entering clerk rarely developed into an ideal bookkeeper because he was too much imbued with the spirit of haste to do his work with that neatness and entire absence of erasures on which the skilful bookkeeper prides himself.

A frequent substitute for the entering-desk is found in the plan adopted by Messrs. Bevan & Kirk. The day-book entries are made throughout the day—whenever, in fact, orders are ready for despatch. The junior clerk makes out the invoices from the day-book, and they are either sent under separate cover along with the goods, or separately by hand, or by post, as the case may be. Yet another variation is to write out the invoices in copying-ink from information supplied by the persons who executed the orders and from the orders themselves. As press copies of the invoices are taken, it is not strictly necessary to repeat in the day-book all the information contained in the original invoices. Consequently the day-book shrinks to a bare record of dates, names, and amounts.

The modern universal tendency towards the subdivision of labour is quite as effective in business circles as elsewhere. As a rule, no ledger clerk would be allowed to act regularly as buyer, no salesman as cashier; nor would a factory foreman be allowed to combine the functions of a general manager. Therefore, it is imperative to arrive at an early decision—let us say, between the ages of 17 and 20—on the all-important question: "What are we going to make of our lives?"

Continued

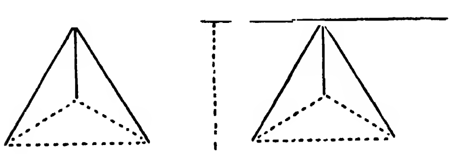
WHAT GRAVITATION MEANS

Kepler's Laws and Newton's Deductions. Universality of the Law of Gravitation. The Simplicity of the Law and its Wonderful Meaning

By DR. C. W. SALEEBY

Three Kinds of Equilibrium. Three kinds of equilibrium are usually described—*stable, unstable,* and *neutral.** A body is said to be in a state of stable equilibrium when it tends to return to its original position after the temporary application of a disturbing force—the book lying on the table or a weight hanging at the end of a string are in stable equilibrium. In the case of any given body, it is often necessary to ascertain the conditions of stability or of stable equilibrium.

Let us take, for instance, a three-legged stool. If this be slightly tilted, it will come back to its original position, and it is found that in the case of such a stool, or any other body which is supported at a series of points, the conditions of stable equilibrium are satisfied when the vertical line dropped from the centre of gravity of the body in question falls within the figure formed by joining all the points of support. If, for instance, the three-legged stool has a very wide top and we place a heavy ball upon the edge of this top, the whole thing will topple over—the centre of gravity has been shifted, and the vertical line dropped from it reaches the ground at a point outside the figure formed by joining the three points at which the stool is supported.



A body is in a state of unstable equilibrium when the temporary application of any new force causes a permanent change in its position. An egg may be balanced on its end for a moment, and during that moment there is equilibrium; but it is unstable because the very slightest displacement cannot be recovered from, as it can in the case of a weight hanging from a string.

The Case of the Billiard Ball. Midway between these two is neutral equilibrium, in which the body, when a new force is impressed upon it, undergoes a change of position without returning to its original position, but without continuing to leave it. A billiard ball, for instance, is in a state of neutral equilibrium on a billiard table. When gently pushed, it moves a few inches and then comes to rest. That its equilibrium is neutral but not stable is evident when we contrast its case with the weight hanging from the string, for when the weight is pushed, just as the billiard ball is pushed, it not only comes to rest as the billiard ball does, but it comes to rest in the original position, whereas the billiard ball comes to rest at a distance from it.

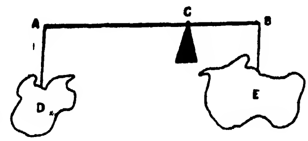
Let us turn now to the consideration of forces tending to produce rest in virtue of their interaction. Suppose that the forces be parallel, as in the case of a rod balanced upon a point by means of a weight hanging from each end of it. We must suppose also that the rod has no weight of its own, else the case becomes too complicated. Let us imagine that the two arms of the rod are of unequal length, the weight hanging from the end of the shorter arm being heavier than that hanging from the longer arm, but the proportion between the two being such that the rod is balanced. Here we have two downward forces, one acting at each end of the rod, and they are exactly counterbalanced by an upward force which acts at the point where the rod is supported, and which consists of the resistance offered by the supporting point to the forces represented by the two weights hanging from the two ends of the rod.

Principle of Moments. Now we find that the rod remains balanced—that is to say, equilibrium results—only on this condition, that the force represented by the one weight multiplied by the length of the arm to which it is attached be equal to the force exercised by the other weight multiplied by the length of its arm. This exceedingly important proposition, which is true in all cases, simple and complex, is known as the *principle of moments,* a technical term which involves the definition of the word *moment.* The language employed is really very stupid, for surely anyone is entitled to think that *moment* and *momentum* have the same meaning, the first being obviously the English of the second, which is a Latin word. But they have two totally different meanings. By momentum, as we saw, is meant the quantity of motion, but the word moment is a description of a much more complicated idea. In the case of the weights hanging from the ends of the rod, the moment of the force represented by one of the weights is the product of that force and the length of the arm of the rod from which it hangs. This must now be put into more abstract language.

We have seen that the point where the rod is supported, or the fulcrum of the lever, exercises a force vertically upwards; the arm of the rod is therefore at right angles or perpendicular to the force exercised by the fulcrum; hence we may say that the moment of the force is the product of the force into a perpendicular dropped

* See "Centre of Gravity," later in the course.

from the fulcrum upon its line of action. Even this statement may be made more abstract still, thus: The moment of a force about a point is the product of the force and the perpendicular from the point to the line of action of the force. This sounds very difficult, but it is simple enough if we read it over carefully in connection with such a diagram as this.



In the diagram, C is the "point" of the definition, D or E represents the force of the definition, and AC or BC represents the perpendicular from the point to the line of action of the force.

The Lever. Now, the principle of moments underlies the whole theory of the lever. In the simplest and most useful kind of lever we find, for instance, a man exerting a small force at one end of a rod, which results at the other end in the motion of a very heavy object which the man could not possibly have moved directly. This is the principle of the crowbar.

The fact that determines the movement desired is the adequacy of the moment on one side of the fulcrum as compared with the moment on the other side. The *force* the man applies may be small, but this is multiplied by the length of the long arm of the lever, and hence its *moment* is adequate. That is to say, it is equal, or more than equal, to the *moment* of the force acting on the other side of the lever. It might easily be shown that nutcrackers and scissors and pincers are cases of levers which act in a similar fashion.

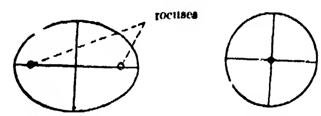
The Discoveries of John Kepler. The discussion of the third law of motion is deferred to the chapter in which we deal with the conservation of energy and the relation of this great principle to the facts of dynamics. We may conclude the present discussion of motion in general by the statement of the three laws of planetary motion discovered by the great astronomer John Kepler (1571–1630).

This illustrious genius was born at Weil in Wurtemburg. He had a miserable childhood, for not only was he born prematurely, like Newton, but his hands and his eyes were permanently injured by an attack of small-pox in his fourth year. Destined for the Church, Kepler turned to astronomy, to his great regret, in his twenty-third year. He soon became dissatisfied with the chief business of a German astronomer in those times—the making of almanacs that prophesied the future from the movements of the planets—and he attempted, but in vain, to reduce these movements to law. It was not until many years later, in the first decade of the seventeenth century, that his ceaseless labours of observation led to memorable results. He had bad health, he was not a great mathematician, he was overwhelmed with domestic cares, but he left an enormous mass of accurate and precise observations.

Three Laws of Planetary Motion. His many years of labour enabled him to arrive at the three great laws of planetary motion now to be stated.

1. *The orbit of each planet is an ellipse with the sun in one focus.*

An ellipse is a closed curve, symmetrical about two axes, which are at right angles to one another. Within this ellipse there are two points, each of which is called a focus. It is plain that if the two axes become equal the ellipse is converted into a circle, and the two focuses coincide. [See GEOMETRY in DRAWING.]



ELLIPSE CIRCLE

From this law Newton inferred that the attractive force which keeps each planet in its orbit varies inversely as the square of the planet's distance from the sun. Newton inferred the existence of this attractive force from the second of Kepler's laws, which is as follows:

2. *The radius-vector of each planet describes equal areas in equal times.*

The radius-vector is the line drawn from the sun to the planet. It follows from this law that the velocity of the planet must be greater when it is nearer the sun than when it is farther away.

3. *In the case of each planet, the square of its periodic time bears the same proportion to the cube of its mean distance from the sun.*

The periodic time is the time taken in journeying once round the sun—one year for the earth and 165 of our years for Neptune. The mean distance is usually taken as half the length of the longer axis of the ellipse which represents the planet's course.

How Newton Deduced his Theory. We have already seen what Newton inferred from the first and second laws; from the third he inferred that the attractive force which keeps the planets in their places is the same for each planet—that is to say, is the same absolutely, though we have already seen that it varies inversely as the square of each planet's distance from the sun. Hence Newton concluded that it must be one and the same force, directed to the sun, which keeps each planet in its orbit.

Before Kepler's day it was thought that each planet moved in a circle round the sun at an unchanging speed. These remarkable discoveries of Kepler were thus absolutely essential to Newton's discovery of the law of gravitation. Since Newton's time it has been proved by mathematicians that Kepler's second and third laws are necessarily deducible from the first.

The reader must clearly distinguish between Newton's laws of motion—three in number—and Kepler's laws of planetary motion, also three in number, which latter constitute the data from which Newton made the crowning inference of the law of universal gravitation. This is the great subject which we are now about to consider.

WHAT GRAVITATION MEANS

The law of universal gravitation is as follows:

Every particle of matter in the universe attracts every other particle with a force which is in the direction of a straight line joining the two, and whose magnitude is proportional to the product of the masses, and inversely proportional to the distance, between them.

This may be stated in slightly different language. Every portion of matter attracts every other portion of matter, and the stress between them is proportional to the product of their masses divided by the square of their distance.

Now, before we go any further, we must distinguish once and for all between a law and a cause—what, in fact, is this statement of the law of gravitation? It is what is called in philosophical language a *generalisation.* Indeed, all the laws of which we speak in science are generalisations—that is to say, general ways of stating the common character of a large number, perhaps infinitely large, of particular facts. Now, it is plain that there can be no final generalisation as to such a matter as gravitation, since it is plain that we cannot possibly examine all the particular instances concerning which the general statement is made. All we can say is that in every case we have examined we find that this attraction exists, and that its magnitude is determined according to the conditions stated in the law. We find further, as the case of the discovery of Neptune proved, and as is also proved by innumerable experiences of astronomers, that the law may be trusted as a means of prediction and discovery. We may take it, then, that though we have not examined every case in the universe throughout all past, present, and future time, yet a general statement which is true of all the facts we have observed, and which actually informs us in detail as to innumerable facts which we have never observed, is as much entitled to be regarded as true as is any proposition which the human mind is capable of framing. In other words, we will admit ourselves to be very dogmatic, and, if you like, arrogant, and to say that the law of gravitation is positively true; that we have here the truth, the whole truth, and nothing but the truth—in short, that concerning this law we have nothing more to learn.

Distinction Between Law and Cause. But when we come to consider the totally distinct question, which is nevertheless constantly confused with the previous question, we find that our dogmatism is silent; whereas, concerning the *law* of gravitation we dare to assert that we know all there is to be known; concerning the *cause* of gravitation, we know nothing whatever.

We have laid much emphasis on this point, in the first place because it will lend clearness to our subsequent discussion; but, in the second place, because the distinction between a law and a cause is of cardinal importance in scientific thinking, and because, to our mind, the fundamental distinction between the two finds no illustration so cogent and convincing as the present one.

For we have here a universal principle concerning the details of the operation of which we know everything, but concerning the cause of which we know absolutely nothing at all. Surely we may hope that no reader of this chapter will ever again make the disastrous mistake of confounding law with cause, a mistake which has led to more controversy and confusion in science and, notably, in the conflict between science and dogmatic theology, than any other that can be named.

Universal Gravitation. First, then, as to the facts of universal gravitation, which will occupy us at much length, before we spend a few paragraphs in a discussion of the attempts that have been made to explain them. At present we are concerned merely with description, with the fact of the law of gravitation; later we shall be concerned with explanation, the cause of the facts which we have described.

Newton was led, as we may remember, to this supreme discovery by the contemplation of a falling apple; and gravitation is in the first place a terrestrial or earthly matter. It does not need a Newton to know that unsupported objects fall to the earth; and if they fall, it must be that some force has been impressed upon them; our study of the first law of motion has taught us that. It is plainly a great step from the assertion that the earth exerts an attractive force upon an apple to the assertion that the sun exerts an attractive force upon the earth, and to the further assertion that the apple attracts the earth, and the earth the sun.

For very many years the truth of the law of gravitation could not be asserted save of the earth, objects upon the earth, and the planets in their relation to the sun—that is to say, gravitation was a truth of the solar system, but we could positively say no more. The French philosopher, Auguste Comte, declared that we should never be able to assert whether or not gravitation acts amongst the stars. He was wrong, for less than fifty years after his death we are able to say that the facts recorded in an enormous and constantly increasing number of observations do demonstrate the action of gravitation amongst the stars. We are, therefore, now justified in believing that it is an omnipresent force.

If Gravitation were Abolished. Some of the more immediate indications of gravitation have already been indicated. We saw in a previous chapter that we must carefully distinguish between the two words "mass" and "weight"; we saw that the mass of a body is the stuff it contains, but that the weight of a body is merely the outward indication of the force of gravitation between the earth and the body in question. If gravitation were abolished it would require no effort whatever to lift by one finger a weight of a million pounds, but there would be as much stuff in the object lifted as before; its mass would be unaltered. Hence in the case of the planets and the stars, astronomers never think of talking of their weight; the term has no meaning, for gravitation is acting upon them in all directions. We can only conveniently

talk of weight where, as in the case of a stone held in one's hand, gravitation is for practical purposes acting only in one direction—*viz.*, downwards. Thus by weight we mean the downward force of gravitation, but downwards means nothing when applied to Sirius or Jupiter. Astronomers may, therefore, talk of the mass of the heavenly bodies and of their density, which is the relation of their mass to their size or volume, but never of their weight.

As we have seen, then, if gravitation were abolished we should all be strong men, and if its force were altered, as it would be by our transference to a smaller or a larger planet, such as Mars or Jupiter, the possibilities of our lives would be very much modified; but it has nowhere been clearly enough stated that, according to the prevailing theory, we owe our very existence to gravitation!

Energy and Shrinkage of the Sun. Everyone knows that the earth owes its energy to the sun, the source of all our light and heat, without which life could never have been evolved upon the earth, and with the extinction of which it must necessarily cease. Now, according to the theory of the great German physicist, Hermann von Helmholtz, the sun obtains energy from its constant shrinkage, and this shrinkage is due to the mutual action of gravitation between the innumerable atoms of which the sun is composed. Quite recent research has shown that, in all probability, gravitation is not the sole source of the solar energy, but it is at the very least an important contributing source of the power in virtue of which human life is possible.

Gravitation having given us life, and ever binding us to the sun—from the company of which the earth would soon separate herself in virtue of Newton's first law of motion but for the constraining power of gravitation—this great principle proceeds to supply man's mind with the most striking proof of what is perhaps its most lofty conception. This conception is that this great and various world of ours—flowers and stars, educators and elephants, men and meteors—is what we rightly but uncomprehendingly call a universe—that is to say, all are in reality one. It is Newton's law of gravitation that furnishes us with the most powerful support for this belief. The poet is actually right who says:

"Thou canst not stir a flower
Without troubling of a star."

A Wonderful Thought. If the law of gravitation be true, you cannot stir a flower, you cannot even cause movements of matter in your brain in the mere intention to stir a flower, without thereby altering the position, in accordance with universal gravitation, of all the matter in the universe. As the present writer has ventured to say elsewhere, every breath we draw affects the path of Sirius and the Pleiades.

Another point which we consider to be inadequately emphasised is the extreme simplicity of this universal law. This simplicity becomes more striking when we realise that a similar statement to that of Newton holds good of certain important facts of magnetism and electricity.

The Marble and the Star. The simplicity of the law of gravitation is so striking that it leads to a very interesting speculation as to the cause of gravitation. The cause underlying a law so simple must itself be very simple. The law states that not only every atom in the universe attracts every other, but that the force with which they do so bears the simplest possible relation to their mass and the distance between them. If the mass be added to, the force is added to in proportion. If the distance be doubled, the force is reduced to a fourth of what it was before. The law holds to a hair, however you alter the conditions as to distance, or mass, or disparity of size between the two bodies we consider. It holds whether you deal with a couple of marbles on the table before you, or with the mighty star Sirius and that invisible dark companion of his which the law of gravitation has discovered for us, or with one of the marbles and Sirius. Plainly, therefore, the cause of phenomena so constant, so invariable, yet capable of such very simple expression, must itself be constant, invariable, and simple.

Three Facts. Let us note one or two facts corroborative of the law of gravitation and of the assertion that it is universally applicable. We find, for instance, that the weight of a body is equal to the sum of the weights of its parts; that a spherical shell exercises no attraction upon a particle in the centre—that is to say, appears not to exercise such attraction, because the attraction, in accordance with the law of gravitation, is equal in all directions. Thirdly, we find that a spherical shell acts on a particle outside it with a force the direction of which is through the centre of the sphere, and is exactly equivalent to the force which would act on the particle if the whole mass of the sphere were condensed at its centre.

Since we know that at any one place the weights of all bodies are proportionate to their masses, we know that the force of gravitation varies in proportion to the masses of the mutually attracted bodies. The last statement in the law, the "law of inverse squares," is a necessary deduction from Kepler's laws of planetary motion, which, as we have seen, are simply general statements of facts.

Continued

THE HEBREWS & THE GREEKS

Group 15
HISTORY
5

Continued from page 502

Hebrew Race. The Mosaic Law. Jericho Destroyed. Solomon's Reign. The Babylonian Captivity. The Rise of the Greek Race

By JUSTIN McCARTHY

THE earliest appearance of the Hebrew race, that race which has performed in the world's progress so important a part, belongs to the dawn of history. We learn much of its story from the narrative bequeathed to humanity in the Old Testament, sustained as it is by many monuments and human records. The Hebrews trace the opening of their historic progress back to Abraham, who came from Chaldea and settled in the region of Canaan 2,000 years at least before the Christian era. In the region between the Nile and the Red Sea, a land most fertile and ready for cultivation, the Hebrews rapidly increased and multiplied, although the Egyptian occupants of the soil treated them for a long time as underlings, or, indeed, as if they were mere captives of the bow and spear.

The Hebrew Race. The Hebrews were from the outset a conquering race, though not in that merely physical sense which is usually associated with ideas of conquest. From the dawn of history down to the present day the Hebrew—or the Jew, as we now call him—has always made himself an influential and even a ruling figure, in fact at least, if not in title, among every race in whose movements he has come to take any part. The narrative of the Old Testament tells how Joseph, sold as a slave in Egypt, rose by his intellectual and practical capacity to become one of the Ministers of the Pharaoh Sovereigns, and this early record fitly illustrates the story of the race. Throughout the history of the world, since its earliest records, the Hebrew has been persecuted in every country, ancient or modern, where he endeavoured to establish himself as a citizen. It must be owned, too, that the Hebrew when he had the opportunity has shown himself as ready and as capable of instituting religious and caste persecutions as ever his enemies have been; but in the power of maintaining himself against all such oppression, however resolute and steady in its continuance, he is almost without a rival in man's history.

Birth of Moses. In the region where the Hebrews settled they soon began to multiply greatly, but they made no intermarriage with the Egyptian population. The story of the finding of Moses serves to illustrate most effectively the traditions which tell us how the government of the Pharaohs endeavoured, by the ruthless exercise of tyranny, to check the growth of the hated Hebrew race. An Israelite woman gave birth to a male child at a period when the ruling sovereign of the Pharaohs had issued an order that all male infants of Hebrew women should be killed at birth. The Hebrew woman, after having concealed her child for three months, began to fear that she could not much longer prevent its existence from being discovered by the enemies of her people. She put the child in a basket of bullrushes on the Nile, where the daughter of the reigning Pharaoh was accustomed to bathe every day. The wailing of the child drew the attention of the princess, who had a woman's heart, and was moved to genuine compassion by the infant. She brought him up in her own palace, and had him instructed by the best teaching which the Egyptian priests could give him.

The Pharaohs. The child was named Moses, meaning "drawn out," because he had been literally drawn from the waters of the river. Later on the mother of Moses found access to him, made known to him the secret of his birth, and revealed to him the whole story of the persecutions inflicted on his race by Egyptian rule. Moses, now growing up, saw one day an Egyptian beating and ill-treating one of the Hebrews, and he killed the Egyptian aggressor.

Knowing what the consequences of this act must be, Moses escaped from that region and made his way to Jethro in the southern extreme of Arabia Petræa, where he found the ancient faith of his forefathers prevailing. He thereupon resolved to devote himself to the task of delivering those of his race whom he could influence from the tyranny of the Pharaohs, and to lead them "out of the house of bondage." He asked Pharaoh to allow him and his people to go "three days' journey into the desert and sacrifice unto the Lord our God." The recent discoveries made by Dr. Flinders Petrie, in Sinai, have brought to light some evidences in stone that there was near Sinai in the days of Moses a Semitic temple, a central place of worship to which the Jews and their kindred peoples were accustomed to resort, and that this was the temple which Moses proposed to reach by the three days' journey into the wilderness.

The Law of Moses. The world is familiar with the story of Moses. He and Aaron the Levite led the Hebrews and their herds into the desert, where they wandered for long in the Arabian plains. There he spread the doctrine of the one Divine Being, and enforced his teaching by the promulgation of ordinances and laws which showed, and show, an entire superiority over every other system of legislation known to the world at that time. He abolished the distinction of castes, and declared the equality of all citizens before the one Divine Spirit, and before the existing law; emancipated slaves, and ordered the restoration of alienated property to its real owner. The laws of Moses

always protected the poor, forbade usurious practices, proclaimed the virtues of charity and almsgiving, enjoined kindness to strangers, and insisted on kindly dealing even with the lower animals. The Mosaic system was a complete reversal of the principles then prevailing in the world outside. The stranger was to be treated as a friend and not as a natural enemy; the slave was restored to the position of a free man, and the wife was allowed to take a place of equality beside her husband. The Decalogue—the interpretation of the whole moral code by ten commandments—is the outcome of that time of marvellous and inspired legislation.

Destruction of Jericho. It was the desire of Moses that his people should return to the ancient land which had been chosen by Abraham for a settlement. Joshua, who succeeded him, traversed the Jordan with the object of settling there, destroyed the city of Jericho, and partitioned the soil of Canaan among the twelve tribes of Israel. But when Joshua died the government of the ruling elders was not strong enough either to ensure the Israelites the occupation of the land or to resist the invading impulses of foreign rulers. Sometimes the Hebrews were reduced for a while to complete servitude, and then were rescued again by heroic and patriotic men of their own race, who made for themselves an era of sovereignty—in fact, although not in name, and the Hebrews before long accepted the dominion of an actual king.

This was Saul, of the tribe of Benjamin. Saul was selected for this office by Samuel, who had been practically the ruler of the people and who was induced, or compelled, by the demands of his people to set a Sovereign over them. The administration of Saul at first seemed to promise great success, because of his capacity for the resisting of encroaching enemies and the moderation and the wisdom of his rule.

The Rule of Saul. But Saul seems to have gradually changed his nature because of the temptations offered to him by his position, and to have endeavoured to make himself an absolute dictator without any regard for the sacred traditions and long established habits of his people. Then came the era of David, the son of Jesse, a Hebrew shepherd, whom Samuel had already anointed as King. He was introduced into the Royal household with a hope that he might one day become the actual ruler in the place of Saul, who was growing to be more and more distrusted and disliked among his people. David had won for himself the admiration of the Hebrews by killing the Philistine giant, Goliath, but by this feat he aroused the jealousy and hatred of Saul, who made many attempts to get rid of him, and even attempted more than once to kill him.

Saul was afterwards killed in battle. And then the tribes of Judah and Benjamin, and finally the other ten Israelite tribes, accepted David, who had married Saul's daughter, Michal, as their Sovereign. David proved himself a powerful leader. He captured Jerusalem, completely defeated the Philistines and the Moabites, and spread the Hebrew kingdom to the Euphrates on the north, and to the Red Sea on the south. His rule was for a long time a complete success. He established effective laws for the maintenance of religious worship, for the administration of justice, for the support of a sufficient army: and he initiated and organised the arrangements for the building of the great Temple. David lived in Jerusalem, which was then called the City of David. His later days were troubled and darkened by the revolt of his sons Absalom and Adonijah. He died somewhere about 1,000 years before the Christian era. He has well been styled "The sweet singer of Israel," for he must ever be regarded as the original inspirer of the marvellous religious lyric poetry of the Hebrew race, and his name must live for ever in all human history.

A Time of Prosperity. Solomon, the son of David, succeeded to the rule of the Hebrew race. By this time the remaining populations who had belonged originally to the soil of Canaan—among them the Philistines, Edomites, Amalekites, Moabites, and others—had been brought under the rule of the Hebrew kingdom, and Jerusalem was made the capital of the ruling race. Solomon's was in every sense a splendid reign in its earlier days. The cultivation of arts, and especially of architecture, made itself manifest everywhere. Poetry and music held a leading place in the intellectual glories of the period, and indeed suffused the minds and feelings of the population to a degree never known before in any part of the world, and hardly excelled even in the most palmy days of Greek and Roman culture—hardly surpassed, perhaps, at any later period of human history.

Commerce also began to thrive in a manner new to the world, and the trade of the kingdom was carried on with Egypt, India, and Ceylon, and with regions and islands still farther off. Solomon was indeed one of the most brilliant and picturesque figures of whom history gives us any record. He was unquestionably a man of superb intellect. His mind was endowed with a marvellous combination of practical wisdom and of imaginative power. It is more than probable that oracular sayings, imperial projects, and intellectual triumphs have come to be ascribed to him which were not actually the offspring of his own intellect; but even this is only another evidence of the immense influence which he must have exercised over his contemporaries and over their descendants through many successive generations.

End of Solomon's Reign. A great man is always thus invested by tradition with some intellectual triumphs to which he himself might have laid no claim, and the tendency of posterity thus to exaggerate the greatness of any ruler of the past is but another and a very impressive tribute to the position which he must have acquired among those over whom he came to rule. There can be no doubt that the artistic genius of Solomon became to some degree a great trial to the people. He was a voluptuary of the most lavish and uncompromising order, and even some of his noblest artistic and architectural achievements began to create heavy burdens for his over-taxed

subjects. He spent money in the most prodigal fashion, and his enormous resources of money did not enable him to gratify to the full his genius for artistic splendour. He had to lay heavy taxes on his people, who grew poorer and poorer under his rule; and towards the close of his life the burden which he thus imposed upon those who were compelled to yield to his demands made his reign increasingly oppressive to a large proportion of those whom he governed. His renown had spread everywhere over all surrounding regions, and the Queen of Sheba was induced to visit the ruler of the Hebrew race.

As the close of his life drew on he appears to have accepted the ordinary position of a despotic Eastern Sovereign, and he was charged with having decided according to his own arbitrary will many questions of judgment which ought to have been settled according to the recognised and traditional principles of religion and established law. He was charged with having departed so far from the faith of his fathers as to encourage, and even to patronise, idolatrous practices, and to make the authority of the priesthood depend entirely upon his own caprice. His reign continued to degenerate steadily in its later periods from the magnificent opening of his career; some of the outer populations rose in revolt against his ordinances, and even his own people often turned against him.

Israel and Judah. After Solomon's death the dissatisfaction which had been growing up among his subjects broke into actual dissension. For it seemed impossible at the time to obtain any common agreement among all parties and sections as to the proper means of restoring general content and prosperity. The monarchy soon divided itself into two separate sections: one the kingdom of Judah under Rehoboam, Solomon's son, and the other the kingdom of Israel, under Jeroboam, the Ephraimite. The kingdom of Judah was made up for the most part of the tribes of Benjamin and Judah with also, it would seem, the inhabitants of some outlying cities and provinces. The kingdom of Israel included the remaining ten Hebrew tribes.

Nineteen kings succeeded each other in Israel, but these kings did not come to their ruling places as regular successors in the same dynasty. Most of them became rulers by actual conquest, by seizing the throne, and in some instances by putting to death their predecessors. Then the region over which they ruled was invaded and conquered by Shalmanezer, Sovereign of Assyria. Hosea, the King of Israel, was immured in prison, many of the Hebrew people were sent as captives into the far eastern regions and the mountainous districts of Media, and their lands were occupied by Assyrian settlers. These new colonists mixed themselves with the Israelite population still left in the land, and by their inter-marriages were formed the race described as the Samaritans.

Nearly 600 years before the Christian era Nebuchadnezzar, King of Babylon, captured Jerusalem, burned the Temple, and carried off some of the most distinguished and wealthy of Jerusalem's inhabitants as prisoners to Babylon. Then followed that period in the history of the Hebrews which is known as the Babylonian Captivity. The Israelites who had been forced into exile before the exile of the race of Judah occupy no distinct place in history after this period. Those of the Hebrew race who formed the kingdom of Judah seem to have been treated with comparative mildness by the rulers of Babylon, and came to exercise a strong and general influence over the people of that kingdom. The region of Babylon became the "second land of Israel," and remained so for many centuries.

A New Chapter in Man's Development. We must pass away now for the present—but only for the present—from the story of the Jewish race. The most important event in the history of that race—the most important event, indeed, in the history of the world—was yet to come, but it belongs to a period when great peoples and great realms had arisen in Europe on whose influence over the progress of human civilisation the historian has yet to tell the marvellous tale. Europe was about to open an entirely new chapter in the history of man's development, and in that development the Hebrews came to perform a most important part. Europe, Asia, and Africa now begin to be blended in the world's movements, and the Hebrews cease to be, and Asia herself ceases to be, separate and isolated influences over the working out of man's earthly destiny.

Meanwhile, the influence of the Holy Scriptures was beginning to diffuse itself in the Eastern world. The name of the Bible is taken from the Greek word "biblos," which means a book, but is adopted in special and exclusive reverence to the consecrated writings. The teachings which are embodied in the book of Genesis are believed to have been already making their way into the world's knowledge some 4,000 years before the birth of Christ.

The prophets were teaching down to some 400 years before the Christian era. The Scripture history of the Jews ends, according to Latin writers, about that time, and from thenceforth we take what we know of Jewish history from the accounts given to us chiefly by Roman authors.

The Rise of the Greek Race. Greece opens the next momentous era in the civilisation of the world. In war and in peace, in all departments of literature and art, Greece won for herself a fame in her early days which no succeeding age has been able to outrival. Greece, with her islands, was happily situated for the work which she had to do. In the extreme south-east of Europe she had the western shores of Asia almost within speaking distance, and the Mediterranean Sea spread itself around her southern shores. Her history goes back to blend with that of the Hebrews and the Persians, and the name of her great poet, Homer, carries us far into antiquity. The Greeks were navigators from the very beginning, and loved to make their way into far foreign regions and study there the movements of a life which was

new to them, and, in many of its characteristics, widely different from their own. Greece is a small country, and yet there is no part of the world in which from the opening of her civilisation she has not made her influence felt. The modern world—if we include in that phrase the whole Christian world—has never produced greater narrative poems than those of Homer, greater dramas than those of Æschylus, Sophocles, and Euripides; greater works of philosophic thought and critical disquisition than the writings of Socrates, Plato and Aristotle; more vigorous and vivid satirical comedy than that of Aristophanes. The sculpture and the architecture of classic Greece are the world's wonder, and the traveller, from whatever land he comes, must feel that he is looking on one of the noblest works of man's making as he stands upon the Acropolis and gazes on the Parthenon.

Early Days of Greece. Greece is but a small country, even if we include the islands which belong to it; one of which, Crete, much exceeds in its size any of the other islands. Yet, in the days of her greatness Greece was famous as a conquering warrior state no less than as the home of literature and the arts. The earliest inhabitants of Greece, so far as we can trace back the history of the country, appear to have been the Pelasgi, who belonged to the immemorial Aryan race. *The coast of Greece is, when considered relatively to the size of the country itself, the longest coastline of any country in Europe, and* this fact enabled the Greeks to become incessant voyagers to other shores, and at the same time induced and permitted the inhabitants of foreign but neighbouring regions to make incursions into Greek territory.

Greece is much intersected by mountain ranges, and these became barriers dividing the Greeks into small and separate petty states, and thus prevented them, in some instances, from making a prompt and general resistance to foreign invasion. The earliest known religion of Greece appears to have inculcated the worship of many gods, each representing some attribute of the human mind, and even in certain instances the worst passions of man. The Greek deities thus created bore, for the most part, the forms of human beings. Their supreme divinity was Zeus, or, as the Romans called him, Jupiter; Apollo typified imagination and poetry, and there was a strong belief in a future life, when virtue was to be finally rewarded and vice punished. There seems to have been in their religious faith no distinct idea as to any relevation, and their creed came rather from within than from without.

The Founders of European Civilisation. The Greeks were undoubtedly the founders of European civilisation. We need not here pause to retrace the merely poetical and mythological history of Early Greece as told in the great poems of Homer and of other illustrious poets and dramatists in the classic days of Greek literature. We have the books themselves to consult, and many of them are well known to most readers at the present day. We need not tell of the capture of Helen and the siege of Troy which followed it; of the wrath of Achilles and of the troubles it brought upon the conquering Greeks; of the fall of Troy and the fate of Hector. Indeed, the supposed history of the author himself is almost as mythological as that of the gods and goddesses who move about in his pages bearing the forms of men and women, who seem to be animated by many of the most selfish ambitions, the meanest prejudices, and the most unreasonable passions which belong to humanity itself.

The Dorian Invasion. There are many English translations of Homer's works, Pope's being far the most popular; Chapman's earlier rendering was hardly known. Pope's is fluent, and even fascinating; but its style and metre are essentially not Hellenic. The eminent parliamentary leader, Lord Derby, has given to the world an admirable version of the Iliad in English blank verse, and the American poet, William Cullen Bryant, began, but did not quite complete, a blank verse translation which promised to be the finest of the kind in English.

We must come, however, to the earliest records we have of the actual growth of the great nation which had for its principal states Athens, Sparta, Corinth, Thebes, Arcadia, and Macedonia. The most distant record we have of the more or less mythical history of the land tells of the Dorian invasion, which is described by some more or less mythological records as the return of the Heraclitæ, the descendants of Heracles, or, as we now call him, Hercules, who were described as coming back to the land which was originally their own.

First Greek Settlers. The Pelasgi appear to have been the earliest of the Greek race actually settled in the country, and were long afterwards known as the Thessalians. The state afterwards known by the name of Sparta became a great and vigorous rival of the Athenian state. The Spartans were, above everything else, a people of soldiers. One result of the Dorian invasion was the establishment of slavery in most parts of Greece. The Helots of Sparta were slaves whose forefathers had been conquered by the invaders, and were the property of the whole state or camp, rather than of individual masters. Attica was the most highly cultured part of Greece. There were almost incessant invasions of Greece by foreign peoples. These invasions were made the more easy of temporary success by the fact that Greece was divided by its mountain ranges into separate settlements. Cyrus, the Persian monarch, was one of those invaders who attempted to absorb the whole of Greece, but Greece rallied successfully to resist this project.

Continued

Group 10

ELECTRICITY

5

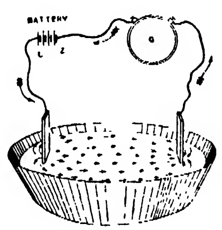
Continued from page 564

THEORY OF THE ELECTRIC CIRCUIT

Circuits through Water and Earth. Return Circuits. Swirling Current Paths. Resistances. Insulation and Insulators

By Professor SILVANUS P. THOMPSON

The Necessity of a Circuit. In order that an electric current may flow at all, there must be a circuit in which it can flow. Electricity will not flow from a battery or a dynamo unless there is a path along which it can return back to the source. When there is provided a system of wires of metal or conductors to lead the current from the battery to the place where it is wanted to do some work and to conduct it back again, we describe this closed path as *a circuit.* If there be in it any gap occupied by air or any other non-conductive substance, even though the battery and the going and returning lines are all in proper order, no current will flow. A circuit which is thus incomplete by reason of the interposition of some non-conductive obstacle, or of a gap, is called an *open circuit.* As soon as the obstacle or gap is bridged over by a conductor, the flow of current begins, and we describe this completed path of the current as a *closed circuit.* Some of the practical experiments suggested on page 463, were for the specific purpose of making clear this necessity for a closed circuit if the current is to flow at all.



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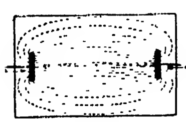

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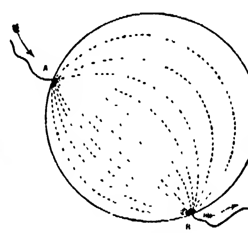
SWIRLING CURRENT PATHS



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Circuits through Water or Earth. It must not be supposed, however, that a current cannot flow in other paths than metallic wires. It is true that for electric bells, electric telephones and electric light, metallic conductors are used both for the outgoing lines and for the return lines. But there are other cases in which a current may flow without being confined to a wire circuit. Water (unless chemically pure) is a conductor, though by no means so good a conductor as any of the metals. This we may easily demonstrate by a simple experiment. Provide a battery of three or four cells, and a simple detector or cheap galvanometer [marked G in **29**], and let them be joined in series between two wires to which two copper plates have been fastened. If these two plates be allowed to touch one another their contact will complete the circuit, and at once the galvanometer will show that a current is flowing. Separate them, by even one-hundredth of an inch, and the current at once stops. Even a gap of one-thousandth of an inch in width, filled with air, or with oil, or dry paper, or any non-conducting substance, stops the current. Now procure a tub or basin filled with water. Dip the plates into this water, keeping them wide apart. You will see, on observing the galvanometer, that the water conducts the current from one plate to the other, but hardly so well as a good metal wire would do. Now bring the plates nearer together, so that the current in flowing from one plate to the other will have a shorter length of water to traverse; on thus bettering the path, it will be seen that more current flows, for the galvanometer will indicate a larger deflection.

Such an experiment might be tried on a much larger scale. Suppose a metal plate to be immersed in a stream or river at some place, and the wire attached to it carried on supports (like a telegraph line) along the bank, and connected, as illustrated in **29**, to one pole of a battery, the other pole of which is joined to a galvanometer, and from the galvanometer let the wire continue along the bank for some distance and then terminate in another metal plate immersed in the stream. It will be found that the stream or river conducts the current and provides a path for the electricity from one metal plate to the other. If the plates are buried in moist earth the effect will be the same, because moist earth conducts. Because water conducts, our electric light mains and wires must be insulated with non-conducting coatings that are waterproof, otherwise some of the current would escape.

Earth as a Return Circuit. When it was found that the earth would serve as a portion of a circuit, it was at once proposed to use the soil as a return conductor in telegraph work (each circuit consisting of one line and an earth return), instead of there being two metal lines, one for the outgoing conductor and one for the return conductor. But in such an arrangement great care must be taken to ensure that the circuit is provided with good metal *earth plates* of sufficient surface, and that these plates are sunk in really wet earth. They will not be effective if too small, or if buried in dry sand or dry rocky ground. Telegraph

engineers habitually talk of an outgoing conductor as the *line*, and the return conductor of a circuit as *earth*, even if it be made of a metal wire. Earth returns are not permissible for electric lighting or for telephonic lines. In a town, a good way of *earthing* a conductor is to connect it by a wire to the water pipes that are buried in the soil instead of using special earth plates.

It is worthy of note that water makes a better *earth*, in the telegraphic sense, than the earth does. It is also worthy of note that when earth is used in any straight circuit as a substitute for one of the conductors, it makes no difference whether the earth be used as the outgoing or the returning line. Also, it should be observed that for many purposes—as, for example, in the use of electric bells, telegraphs, and ocean cables—the earth may serve as return, or, for that matter, as outgoing conductor, if separate metallic returns be used, for more than one circuit at one time. Why many circuits may thus share a common conductor without appreciable interference with one another will be better understood after study of the law that governs electric circuits.

Swirling Current Paths. When a current is flowing through a portion of a large wide conductor, such as a pond of water, a tract of earth, or a large sheet or mass of metal, and is not confined to a linear path along a wire, it spreads out into sheets or swirling paths, occupying the largest cross-section of path available. If a current, for example, be introduced into a rectangular tank of water by means of two small metal electrodes entering the water at one and leaving it at the other, it flows round in curving paths from one electrode to the other, as indicated by the dotted lines in **30**. If a *circular piece of tinfoil* be cut out and laid down on a dry board, and current be caused to enter at the point A at one edge [**31**], and leave it at point B at another place on the edge, the current does not take the shortest route from A to B ; or, rather, though some of it takes the shortest route, a large proportion of it will flow by other and longer routes, as shown by the curved dotted lines. If this circle represented a shallow pond into which water ran in at A and ran out by a drain at B, it would not all run straight across, but would similarly follow swirling curves. In fact, the statement often made that "electricity always takes the line of least resistance" is grossly untrue. In any wide conductor it always takes all the other available paths at the same time. This is true of the flow of electricity through the earth from one earth plate to another.

The Law of the Circuit. Dr. G. S. Ohm discovered in 1827 the law that governs the steady flow of currents in circuits. We have already seen [page 291], that to make any current flow there must be some generator, such as a battery or a dynamo, capable of exerting an electric effort, or *electromotive force*. It was there explained that electromotive forces are expressed in terms of the unit called the *volt*. A volt is not a current ; it is only the tendency to produce a flow. A battery, for example, of 10 Daniell's cells will exert an electromotive force of about 11 volts, whether any current is being drawn from it or not. It was also explained that the strength of an electric current is expressed in terms of the unit of current called the *ampere*. We cannot have amperes unless there be a circuit by which they may flow from the battery (or dynamo) back to the battery (or dynamo). The volts drive the amperes. You can have the volts without the amperes, for the battery or dynamo that is exerting the electromotive force can exist without there being any circuit connected to it. But you cannot have the amperes in the circuit without the volts to drive them. The electromotive force (volts) is the cause ; the current (amperes) the effect. As volts and amperes then stand to one another as cause and effect, we should expect them to show, under given circumstances, a certain proportionality one to the other. And in practice it is found to be so.

Proof by Experiment. Suppose, for example, we had 100 ft. of german-silver wire, of No. 23 S.W.G. (about $\frac{1}{42}$ in. thick), to serve as our circuit, either stretched out as a large loop, or coiled up (properly insulated by being overspun with cotton) on a bobbin. Suppose we applied to this wire an electromotive force of 100 volts, we should find that such is the resistance offered by this long thin wire that even with this electric pressure applied to it only two amperes would flow through it. Now, if without altering the wire in any way we were to vary the electromotive force which we apply to it, we should find the current in the wire, which we should measure with an *amperemeter* [see p. 291], would vary in exact correspondence If we altered the electromotive force from 100 to 200 volts, we should find that the current would of itself alter from 2 to 4 amperes. If we lowered the electromotive force to 50 volts, the current would reduce itself to 1 ampere. The effect would be exactly proportional to the cause.

Had we taken a longer wire, it would have offered more resistance, and then on applying over 100 volts we should have got less than 2 amperes. For example, if we had taken twice the length, it would have offered twice as much resistance, and, in that case, on applying our 100 volts we should have found that the resulting current would be only 1 ampere.

It becomes clear on thinking this over that the resistance offered by the conducting wire to the flow of electricity through it is a measure of the proportionality between the cause and the effect. This is what Dr Ohm expressed in the rule that the current is directly proportional to the electromotive force and inversely proportional to the resistance. To express this in mathematical form, let us write the symbol E for the number of volts of electromotive force, and C for the number of amperes of current. But we shall need a third symbol to express the amount of resistance offered by a conductor, and we shall need a name for the unit of resistance. Clearly,

to fit the other units we must have, as the unit of resistance, a resistance so great that if we apply one volt to it there will be 1 ampere produced in it. A resistance of this magnitude has been called *one ohm*. We will adopt the symbol R to express the number of ohms of resistance that any circuit or conductor offers to the flow of electricity through it. We may now write *Ohm's law* as:

$$\frac{E}{R} = C;$$

or, in words:

$$\frac{\textit{volts}}{\textit{ohms}} = \textit{amperes}.$$

In the case of our German silver wire, it has evidently a resistance of 50 ohms—for if we take $E = 100$, and $R = 50$, we get $C = 2$, as follows:

$$\frac{100}{50} = 2.$$

And if it offers 50 ohms, the effect when we raise the voltage to $E = 200$ will be:

$$\frac{200 \text{ volts}}{50 \text{ ohms}} = 4 \text{ amperes}.$$

So, to use Ohm's law, we may put into words the rule: *To find how many amperes will flow in a circuit, divide the number of volts by the number of ohms.*

Example: How many amperes will flow through a conductor that has 25 ohms resistance when we apply to it an electromotive force of 200 volts? Here $E = 200$, $R = 25$; therefore, dividing 200 by 25 we get as the answer 8 amperes.

Calculations by Ohm's Law. We can change Ohm's law into another form for use in some other problems; for, by transposition it becomes:

$$\frac{E}{C} = R; \quad \text{or,} \quad \frac{\textit{volts}}{\textit{amperes}} = \textit{ohms}.$$

Or we may put this into words as follows: *To find the number of ohms of resistance offered by any conductor, divide the number of volts applied to it by the number of amperes that result as current in it.*

Example: How many ohms of resistance has a wire, if it is such that on applying to it 40 volts we find that the current through it is 12 amperes? Here $E = 40$, and $C = 12$. Therefore, dividing 40 by 12, we find the answer to be $3\frac{1}{3}$ ohms.

There is another useful transformation of Ohm's law, as follows:

$$C \times R = E;$$

or,

$$\textit{amperes} \times \textit{ohms} = \textit{volts};$$

which we may put into words, thus: *To find the number of volts needed to drive a prescribed amount of current through a conductor of known resistance multiply the number of amperes by the number of ohms through which they are to be driven.*

Example: How many volts of electromotive force are needed to drive 40 amperes through a resistance of $2\frac{1}{4}$ ohms? Here $C = 40$, and $R = 2\frac{1}{4}$. Multiplying 40 by $2\frac{1}{4}$, we find as the answer 90 volts as the needed electromotive force.

Further Examples. The following examples, with their answers, are given for practice in working:

1. A glow-lamp of resistance 240 ohms is placed across live electric mains, having a voltage of 100 volts between them. How much current will it take from the mains? *Answer*: 0·42 ampere.

2. It was observed that when wires from a battery of accumulators whose voltage was 80 volts were applied to excite a certain electromagnet, the current which flowed (as measured by amperemeter) was 16 amperes. What was the resistance of the coil of that electromagnet? *Answer*: 5 ohms.

3. The armature of a certain dynamo is known to have a resistance of 0·025 ohm. How many volts will be needed to drive 300 amperes through that resistance? *Answer*: 7·5 volts.

4. A certain line for electric transmission of power was constituted by two conductors, each 110 miles long, each offering 75 ohms resistance. How many volts will be required to drive 20 amperes through these conductors, if the current go through one line and return through the other? *Answer*: 3,000 volts.

Resistance of a Conductor. It is obvious that a wire of given material and thickness will offer a resistance that depends on its length. The longer the wire the more it resists. A little thought will show that if we have wires of the same length and same material, but of different thicknesses, the one that is thicker will be a better conductor, as it has a larger cross-section to carry the amperes; just as a larger pipe will carry a larger flow of water. In fact, the resistance of a conductor is inversely proportional to its area of cross-section, other things being equal. As most conductors in electrical engineering are made of copper, it will be convenient to remember this fact—that a bar of copper 1 ft. long and 1 sq. in. in cross section offers a resistance (at ordinary temperatures) of eight one-millionths of one ohm—*i.e.*, 0·000008 ohm. Hence, if we know the length (in feet) and the cross-section (in square inches) of any copper conductor we can calculate its resistance. As an example, let us take 1,000 ft. of a No. 19 S.W.G. copper wire, which has a diameter of 0·040 in. We must first find its cross-section by the rules of mensuration, by squaring the diameter and multiplying by 0·7854. So we have: $0{\cdot}040 \times 0{\cdot}040 \times 0{\cdot}7854 = 0{\cdot}001256$. Then a piece 1 ft. long will have a resistance of $0{\cdot}000008 \div 0{\cdot}001256 = 0{\cdot}00637$. We divide because the resistance varies *inversely* as the cross-section; and therefore, this wire, which has a section of about $\frac{1}{800}$ of a square inch, will, for equal length, resist about 800 times as much as a conductor that has a section of 1 sq. in. Then, if this be the resistance of 1 ft., multiply by 1000 to find the resistance of 1000 feet; giving the answer 6·37 ohms.

The resistivity of copper—and, indeed, that of all pure metals—increases if they become warm. If ice-cold, the copper rod 1 ft. long and 1 sq. in. in section would have a resistance of

HOW FOOD BECOMES LIFE

Continued from page 580

Process of Digestion. Nature's Device for Sustaining the Human Frame. "The Mission of a Sandwich." Strengthening and Preserving Elements

By Dr. A. T. SCHOFIELD

LET us make a careful review of the actual process of digestion. We shall try to remove the mystery from this function, and give a clear and intelligible picture of what digestion really is. It may facilitate progress and make the picture more graphic if, instead of speaking in the abstract, we take some actual article of food and follow it in its mission of sustaining the human frame. Perhaps we cannot do better than select that peculiar and prehistoric fossil food that so fascinated Dickens at Mugby Junction, as it stood in its glass case for inspection—the ancient British sandwich.

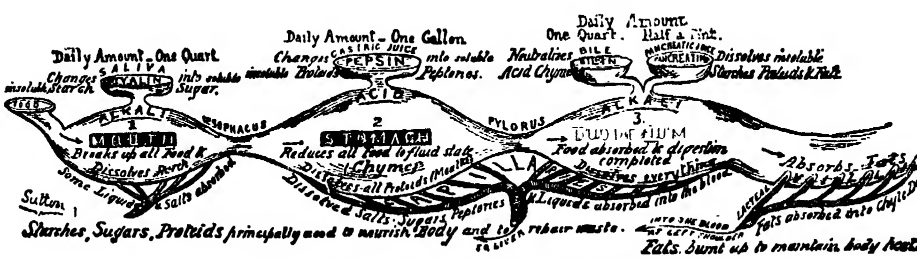
Every Variety of Human Food. It is a painful thought, but none the less true, that this weird article actually contains within its own arid compass every variety of human food. These varieties are four—*proteids, carbohydrates, hydrocarbons,* and *mineral food.* We get the proteids in the meat, however dubious its origin; the carbohydrates in the bread, however sawdusty; the hydrocarbons in the certain fat and very uncertain butter; and the mineral food in the liberal salt, which creates a thirst that is almost unquenchable.

Nothing more than this is wanted for human sustenance; and it is quite conceivable that a man, with unlimited drink, could sustain Nature for an indefinite time on sandwiches alone. It is not recorded that anyone has actually done so in practice.

At the present day we have advanced so rapidly that travellers may search in vain for the interesting fossil that Dickens described, for it is often replaced with appetising and dainty modern substitutes. It still lingers in the glass case, however, at certain country junctions, where it helps lovers of the antique to refresh their memories of the "good old times."

We shall now consider how this sandwich is prepared to be turned into flesh and blood by the tissues. The process is called digestion, and *consists essentially in dissolving all articles of food* so that they can be introduced into the blood, and thus circulated through the body No substance can be considered as food unless it is capable of solution by the digestive fluid, so as to reach the blood. Such substances as cork, stones, fruit-skins, etc., pass through the body unchanged. The one fact essential to remember is that *digestion means dissolving.*

As the digestive tube has no direct communication in any part with the body, all food placed within it is still practically outside the body—just as a train in the Thames Tunnel is not in the river—and the whole purpose of the digestive process is to dissolve the food inside this tube so that it can pass across the walls and into the vessels outside. We will see how this is effected. We have already seen that, setting aside minerals and liquid food that require no digestion, being already soluble, we have carbohydrates, proteids, and fats. Observe, then, that the mouth digestion, or *oral digestion,* is for carbohydrates; the stomach, or *gastric digestion,* for proteids; and the *intestinal digestion* for fats.



36. STAGES OF THE DIGESTIVE PROCESS

In other words, the salt in our sandwich, being soluble, requires no digestive process, but passes straight into the blood, leaving the bread, meat, and fat to be dealt with. How the process is effected in each case we shall consider in detail, and the diagram [36] will help us.

The Importance of Cooking. The food, whether liquid or solid, enters the body by the mouth at the rate of about 2 lb. of solid and 2 quarts of liquid per day. The first important aid to digestion is *cooking,* which acts by rendering the fibres more brittle in meat, and in starchy food by swelling up and bursting the covering of the starch grain. We can see the importance of this. The starch grains are packed in hexagonal capsules—as they always are in grain—which are formed of a tough fibrous material called cellulose. As long as the grains are in these capsules the digestive fluids cannot reach them easily. Cooking, however, softens, swells, and bursts the cellulose walls, and sets the grains free, when they are readily changed into sugar.

In the mouth two changes are effected in the solid food. In the first place, it is ground and cut up into small pieces by the teeth, so as to afford ready access to the digestive fluid ; and, secondly, it is mixed throughout with saliva, which has the power of changing starch into sugar. Saliva is produced at the rate of about a quart a day, one-third being secreted during and *by* mastication, and two-thirds at other times. It dissolves any soluble portion of the food, moistens the rest, and by means of the mucin mechanically lubricates it and renders it easy of deglutition. Its chief action, however, is chemical, and is due to the minute amount of *ptyalin* it contains.

A Vital Factor. Ptyalin, discovered in 1831, is one of a large number of bodies known as ferments, which, by their presence alone, and without undergoing any change themselves, enable changes to take place in the substance acted upon, generally in the form of the addition or subtraction of a molecule of water. Although, therefore, only a trace of ptyalin is found in saliva, it never gets used up or loses its power, but is capable of acting upon any amount of material. It is an unorganised ferment (like the diastase in barley), and the action is, therefore, chemical. Yeast is an organised ferment, and is certainly vital in action. The process of fermentation is retarded or prevented by cold ; and while heat above 140° F. generally destroys the ferment, 212° is certain to do so.

Starch grains, as we have seen, consist of two parts—a covering of cellulose upon which ptyalin cannot act, and which does not colour with iodine, and particles of granulose, or true starch, which colour blue with iodine. Saliva cannot, therefore, digest unboiled starch; hence the necessity of boiling all starchy food long enough to burst the covering and set the granulose free.

The action of saliva is assisted by moderate heat, by a neutral, or slightly alkaline medium, and by the removal of the digested product—sugar. It is retarded by cold, acids, or strong alkalies, and the presence of much sugar. It is destroyed by high temperature.

Observe here that the mouth digestion is *neutral*, the stomach digestion *acid*, and the intestinal digestion (pancreatic) *alkaline*.

Saliva has no action on proteids or fats, or on sugar, gum, etc. The saliva has no digestive power before the sixth month, hence flour foods cannot be digested by infants under that age.

The Transformation of Food. About half of starch food is digested in the mouth, if properly masticated. We see that the oral, or mouth digestion, really concerns only the bread of our sandwich, leaving the meat and fat unchanged; and the result of this oral digestion properly carried out is to change the bread into sugar. Anyone who doubts this has only to chew an old crust until it gets intolerably sweet. Here we get a glimpse of the resources of Nature and the way (to use a golfing term) she gets round "bunkers" she cannot get over. Starch is insoluble in water. We may keep a crust immersed in water indefinitely, and it will never dissolve. Ptyalin is therefore placed in the mouth to change starch into a soluble substance—sugar. It may also be noted that sugar itself requires no digestion, being a soluble substance ; but articles that require no digestion, through being soluble, may yet, from other reasons, cause violent indigestion. To be soluble is not always to be wholesome. Alcohol is an example.

Our sandwich, cooked and carved, is taken into the mouth, and, if properly chewed, the bread is partly turned into sugar, the dry and arid substance is broken up and moistened throughout, formed into a mass, or bolus, coated as it passes into the throat with a sort of glycerine, and propelled down the gullet into the stomach.

Gastric digestion, or digestion in the stomach, consists of two processes—the solution of the proteid, or meat food, by the digestive fluids, and the constant movement of the food, which corresponds partly to mastication. Let those who are inclined to bolt their food remember that the stomach has no teeth, nor have human beings any gizzards, which are a substitute in some animals for teeth.

Digestive Fluid. The *gastric juice* is the digestive fluid of the stomach, and is produced, at the rate of about one gallon daily, by the glands we have already considered. It is a clear, colourless fluid, of sour taste and odour, with a specific gravity of 1001. The chief function of the gastric juice is first to coagulate and convert insoluble proteids into soluble peptones that can pass easily across the wall of the digestive canal. It is essentially an acid digestive, and cannot work in a neutral or alkaline medium. It acts like saliva, by means of a ferment called *pepsin*. The action on proteids is in at least two steps.

Before the food comes into the stomach, from its presence in the mouth, and sometimes even from its mere smell, or the anticipation of it, the empty stomach, pale and nearly dry, is affected by the reflex action of the *sympathetic* and *pneumogastric* nerves, and begins to blush a rosy red as the capillaries become distended with blood. Very soon drops of digestive fluid begin to ooze out from the pits, or glands, all over the surface, and before long a little pool of clear gastric juice is collected. The softened food, thoroughly mixed throughout with saliva, the action of which still continues until neutralised in the stomach, enters from the gullet at the cardiac end of the stomach, and immediately the movement of the stomach begins, while more gastric juice is poured forth. The cardiac entrance from the oesophagus is tightly closed, as well as the pyloric valve at the outlet of the stomach, the muscular walls contract on the contents, and a peristaltic, or spiral wave of motion begins, getting more rapid as digestion goes on. The effect of this is to propel the food rapidly from left to right along the sides, while it returns in another current along the middle.

Every bit of the food is thus thoroughly exposed to the action of the gastric juice. The

value of this part of the digestive process is seen by experiment. A piece of boiled salt beef took *ten* hours to digest artificially with gastric juice; part of the same piece took only two hours inside the stomach, where this violent movement was combined with the chemical action. The length of the digestive process varies with the food taken. It averages four hours. Easily digested articles, such as tripe, take one hour. Pork takes five or six hours.

Dissolution of Food. The semi-fluid contents of the stomach during digestion become more and more acid, and it is believed that this relaxes the pyloric valve, hitherto tightly closed, so that at first the liquid, then the non-liquid parts, pass through into the duodenum, and the second great section of the digestive process is completed.

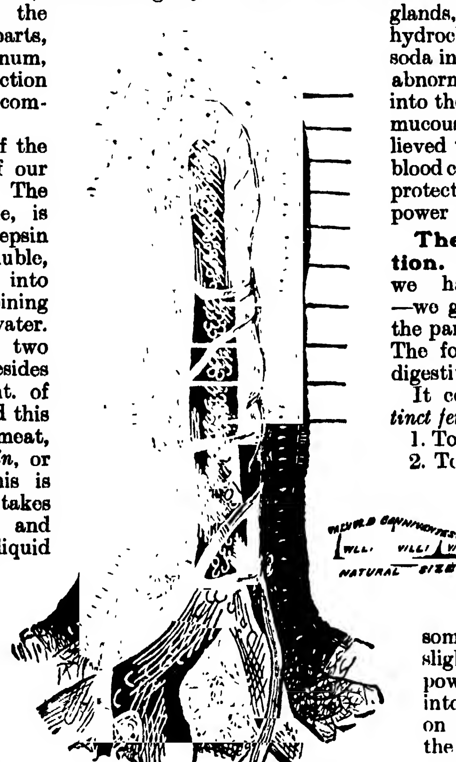
Here, then, the second of the three great constituents of our sandwich is dissolved. The meat, which is insoluble, is formed by the ferment pepsin into peptones, which are soluble, exactly as starch is made into sugar, by chemically combining it with one molecule of water. The actual process is in two steps. Gastric juice, besides pepsin, contains 2 per cent. of free hydrochloric acid, and this acting on the proteids, or meat, makes it first into *syntonin*, or acid albumen. Then this is acted on by the pepsin, takes up a molecule of water, and becomes peptone, or liquid meat—a very different article, by the way, from beef-tea.

This action is aided by heat, acid, sub-division of the food, and its removal as soon as dissolved into the bowel, or duodenum. It is retarded by cold, alkalies, great masses of food, and over-repletion of the stomach.

After use, the gastric juice is reabsorbed. By this time our sandwich has decreased in size. We have supposed it to have been taken into the mouth all at once, as is often done by hurried passengers at railway stations.

The salt, all dissolved in the mouth, and half the bread, changed into sugar, has soaked through into the blood. The meat, changed into peptones, has followed. Only half of the bread and the fat passes on if the process is completed so far. Often, however, it is only partially carried out, and so more goes forward into the duodenum. The "soaking through" is by two methods—*filtration* and *osmosis*. Filtration is fluid passing across the membranous wall under pressure. Osmosis is where two fluids interchange that can mix (not oil and water). Crystalline substances—sugar, salt, etc., filter out readily. Colloid or gummy substances, such as starch and meat, do not. The osmosis is in two parts. The positive osmosis is the flow at first of digestive fluids into the cavities—mouth, stomach, etc.—and the second is the negative osmosis, or the flow out into the blood-vessels of the digestive products.

One question of interest is why the stomach does not digest itself, seeing its walls are formed of proteids. The best answer that has been given is based on the circulation of the blood in its walls. The blood first of all supplies the digestive glands, that take from it the hydrochloric acid, leaving the soda in the blood, which is thus abnormally alkaline, as it passes into the surface capillaries of the mucous membrane. It is believed that this alkalinity of the blood circulation acts as a special protection against the digestive power of the acid gastric juice.



37. A VILLUS

Magnified elevation of mucous membrane projecting into the intestine

The Intestinal Digestion. In the duodenum—which we have already considered—we get two digestive fluids—the pancreatic juice and the bile. The former is the most potent digestive in the body.

It contains at least *four distinct ferments*:

1. To act on starch—*amylopsin.*
2. To act on proteids—*trypsin.*
3. To act on fat—*steapsin.*
4. A milk-curdling ferment—*rennin.*

The *bile*, from the liver, has several actions on the food. In some animals, and very slightly in man, it has the power of changing starch into sugar. It has no action on proteids, but it renders the gastric juice neutral, and precipitates the peptones. It slightly emulsifies fat—*i.e.*, breaks it up into globules—but does not saponify it—*i.e.*, coat it with soap—and acts more powerfully when mixed with the pancreatic juice. By bathing the intestinal walls, it greatly assists the passage of the fat globules across them. It is an antiseptic and a natural laxative, assisting contraction of the intestines. Not more than one-sixteenth of the bile secreted is excreted, and this contains very little of the bile salts.

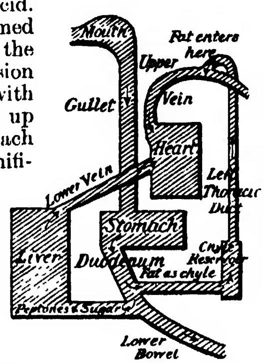
The *succus entericus*, or intestinal juice, may be called a third digestive fluid, and is principally the product of the glands of Lieberkühn. It is a yellow alkaline fluid of specific gravity 1011, containing 2·5 per cent. of solids, largely sodium carbonate. It has a slight power of changing starch into sugar. Otherwise it has no active properties.

We shall now follow our sandwich, which, in the form of acid chyme, has entered the duodenum through the pyloric valve in the third section of the digestive process.

The passage of the chyme over the common orifice of the bile and pancreatic juice at once produces a copious flow, and the acidity of the fluid begins to be neutralised. It does not, however, become alkaline till about the middle of the small intestine, and it gradually becomes acid again after this, especially in the colon.

Complete the Work of Digestion. Any cane sugar in the chyme is almost instantly changed into a more soluble form ; any undigested and even uncooked starch is made into sugar, proteids into peptones, and the fats into a fine emulsion of a soapy nature by the combined action of the bile and pancreatic juice. In short, in the duodenum the work of digestion is completed, and any food left unchanged by the imperfect action of mouth or stomach is changed here, mainly by the pancreatic juice, the meat by the *trypsin* ferment, the starch by the *amylopsin*, the digestion here being strongly alkaline, in contrast to the stomach, which is acid.

We have noticed that the fat is formed into an emulsion by the action of the ferment *steapsin* and bile. An emulsion is a fluid formed by shaking oil up with an alkali. This causes it to break up into tiny, microscopic globules, each coated with a soapy covering (saponification) derived from the alkali, and these, reflecting the light, make it white and opaque, instead of yellow and transparent. Milk is an emulsion, and butter is an oil. Cod-liver oil is a yellow fluid ; shaken up with an alkali (soda) it becomes an emulsion, and is opaque and white, and much more digestible. This fine sub-division is a first step in that incredibly difficult process, the digestion of fat, and is equivalent to the fine sub-division of the food by the knife and the teeth.



38. COURSE OF FOOD FROM MOUTH TO HEART

The difficulty of fat is that it is oily, and no process of filtration or osmosis can pass it through a watery membrane into the blood. Mechanically and chemically it is impossible. Here, then, vital action has to be invoked, and the digestion of the fat of our sandwich differs in principle from that of the bread or meat, in that while these were mechanical and chemical, this alone is truly vital, as we shall see.

Four Million Tubes. While, therefore, all the sugar and peptones, being of a watery nature, can now freely pass into the network of capillaries through the mucous membrane of the intestine, the globules of fat, small as they now are, cannot possibly, owing to their nature, diffuse in this manner. A very special apparatus exists for their absorption.

We have already noticed the rounded elevations of the mucous membrane that project like fingers into the intestine [37]. They average about a line ($\frac{1}{12}$th of an inch) in length, and about 80 or 90 to a square line (or 11,000 to a square inch) in the duodenum, and about 50 in the rest of the small intestines. There are about 4,000,000 in all. They vary in form according as they are full or empty.

Each is composed of a central tube [37], communicating below with the lacteal and lymph vessels in the intestinal walls, and ending above in a blind extremity. This tube is surrounded by a thin layer of longitudinal muscle fibre, which in turn is surrounded by blood capillaries, in loose connective tissue, then a fine basement membrane on which, at the surface of the villus, is a single layer of columnar cells. The free surface of these cells has a fine striated border. These striæ have been supposed to be really processes like the sea anemone's tentacles. They grasp the globules of fat and pass them into their interior. The fat is then supposed to be conveyed across to the lacteal in the centre. This, however, has never been fully confirmed, and more recent observation favours the idea, supported by the behaviour of leucocytes elsewhere, that leucocytes emerge between the epithelial cells, swallow the fat globules, and then convey them across by their own amœboid motion into the lacteal. There may be truth in both views. Anyhow, the fact remains that the fat globules are rapidly conveyed by positive vital action, and not by filtration or osmosis, after being still further sub-divided, into the central tube, which, when full, is pulled down and squeezed empty by the muscles surrounding it, and then springs up empty, to be refilled, the fat passing away into the lymph as a white fluid known as *chyle*.

Inexhaustible Resources of Nature. We may pause a moment to take in this marvellous process, showing the inexhaustible resources of Nature. The fat is first melted to oil by the body heat, then sub-divided into a perfect emulsion, in which state it is brought to these four million elevations, the tiny cells of which greedily seize the globules and pass them into an empty central tube. Immediately it is full this tube, wonderful to say, automatically contracts, and forces the chyle, or emulsified fat, not into the blood, but into another system of vessels altogether—the lymphatics—to be eventually delivered by a further marvellous process into the blood. We thus see that the digestion of the bread and meat is by *chemical* action in each case, one molecule of water being added to the food to make it soluble, but in fat action is *vital*.

As the contents of the small intestine are forced on by the slow peristaltic action of the bowel, all the digested part of the food gets absorbed—the sugar and peptones into the blood, to be carried to the liver, the fat into the lymphatics, and the undigested residue passes on into the colon. The food remains from 3 to 12 hours in the small intestines, and from

12 to 24 hours in the large intestines. Here the principal function is to draw off the remaining water, and the solid residue is excreted at the rate of about half a pound a day. This completes the third, or intestinal digestion, and the whole process.

Four Great Divisions of Food. We must now follow the sandwich, which has at length left the alimentary canal and entered the vessels outside, where it is further prepared for use before it enters the general blood current. Of the four great divisions of human food *three*—the carbohydrates, or sugar, the proteids, or peptones, and the salts and water, or minerals—enter the blood capillaries.

All the capillaries of the digestive system from the stomach, and the whole of the intestines down to the rectum, are collected into one large vein, called the *portal vein*, which runs to the liver, thus conveying three-fourths of the digested food.

The fat alone has a different destination. It does not enter the blood-vessels directly, but finds its way by means of the villi into the *lacteals*, which empty themselves into the general lymphatic stream.

These are so called because the lymph here, being mixed with finely-divided fat, closely resembles milk (*Lac* = milk).

To make the difference clear, we may say, speaking of our own bodies, that when the four articles of food leave the digestive system three of them, the sugar, meat, and salts, turn to the right into the liver; while the fourth, the fat, turns to the left in the lymphatic system.

We propose now to follow the foods through the liver, and then the fat through the lymphatics [38].

The meat, in the first place, enters the liver in the form of unpurified peptones—*i.e.*, liquid digested meat, laden, however, with albumoses and other deleterious products, which are formed in the process of the acid digestion in the stomach, and the alkaline digestion of the duodenum.

The Liver. The business of the liver is to purify the peptones from these bodies, so as to render them fit to nourish the body. When it fails to do this, the body gets poisoned, and we have a bilious attack.

In the next place the sugar has to be dealt with in a remarkable manner. Sugar is such a vital and important food that it must be supplied to the hungry tissues with great regularity in a certain proportion every moment, day and night. How is this to be effected when it is only eaten in any shape two or three times a day? The peculiar glycogenic function of the liver is the answer.

Glycogen is an animal starch, formed in quantities in the liver from the sugar received into the blood by removing from it the molecule of water that was added to it in the starch digestion to make it soluble, thereby rendering it again insoluble. This is stored up in the liver, to be dealt out by re-dissolving it as required.

Glycogen is formed slowly from proteids as well, probably by splitting them up into glycogen and urea. It is found that only half as much glycogen is found in the liver on a pure meat as on a mixed diet.

The object of the formation of glycogen, which is not diffusible, is clearly to store up the soluble sugar in the liver, thence to be re-made as required into glucose.

During digestion more sugar enters the liver than leaves it, but in the intervals twice as much leaves it again as enters it.

Glycogen has been found in small quantities in other tissues of the body. The sugar is finally consumed by the action of the muscle cells, and passes away as water (H_2O) and carbon dioxide (CO_2).

Another function of the liver is the formation of bile. The first function, when more fully understood, will probably be seen to be of great importance in connection with the general question of *autosepsis*, or self-poisoning, which is believed to be more common than is generally supposed.

The blood that leaves the liver by the inferior vena cava (the hollow vein), and thus enters the heart, is laden with the purified peptones into which the meat of our sandwich has been converted, and with the requisite proportion of sugar derived from dissolved glycogen, into which the bread of the sandwich has been changed. We will consider its further destination later on.

How the Food Reaches the Heart. It remains for us now only to trace the dissolved fat, or chyle, to its end. When it enters the lacteals, or "milky" vessels, they pour it with other fluid into the lymphatics, which join together and make their way to the left side of the body, till they enter a reservoir some 2 in. long in vertical height and nearly ½ in. broad, called the *receptaculum chyli*, or the receptacle for the chyle. From the top of this ascends a fine tube 15 in long, called the *left thoracic duct*, which opens into the left arm vein, just behind the collar-bone. This vein carries the blood into the superior vena cava (hollow vein), and so into the heart.

The chyle in the reservoir is pumped upwards along the thoracic duct by the action of respiration, and by movement, and so the fat is poured into the blood, and at length, when it reaches the heart regions, the rest of the digested sandwich, that has been brought there by the other vein from the liver.

Such are the wonderful steps by which all food is carried from the mouth to the heart; and when the difficulties and complicated nature of the process is fairly grasped, it may lead to some increased care in eating, so as not to embarass unnecessarily the natural process by unsuitable food, taken in an improper manner, or in excessive quantities

Continued from page 580

POETRY OF THE ELIZABETHAN AGE

2. The Dramatic Poets. A Review of the Origin and Rise of the Drama, with an Outline of Shakespeare Study

By J. A. HAMMERTON

IT is worthy of note that the Drama in England, so often and long condemned by the puritanical, is not only one of the world's oldest and noblest arts, but had its origin in religious worship. The art which produced in Shakespeare the greatest genius of all time was in ancient Greece an evolution of pagan ceremonial and in its modern revival it might be described as a graft on the priestly propaganda of mediæval times. We cannot, of course, attempt any study of the Greek drama, which, to be made thoroughly intelligible, would require well-nigh as much detail of treatment as our scheme permits our giving to the whole body of English poetry. We can allow ourselves only such incidental references as may be necessary in discussing English drama. But let us be clear on this point: the art of the dramatist, both in the ancient and the modern world, has attracted the mightiest intellects ever devoted to creative literature, and, in proportion to the whole body of the drama, the works of absolute genius which it contains outnumber those in any other division of literature.

The Place of Drama in Literature. It is necessary to state this in the most emphatic manner, because there still exists to a surprising extent a considerable measure of prejudice against everything associated with the theatre; the legacy, on one side, of puritanism, and the outcome, on the other, of the present debased condition of the English drama, which has long ceased to be literary and does not give to the playgoers of our time any inkling of a glorious art. Broadly speaking, our drama is to-day in much the same condition as English poetry during the barren age that separates Spenser from Chaucer, and it is to the written page alone, and not to the theatre—excepting Shakespearian revivals—that we must turn to study the drama. It may be said that this is as it should be, since the dramatist, not less than any other poet, is for the study. But the fact remains that what is called "a drama for the closet" is no drama at all; the play which cannot be acted is for that reason no play, and equally the play which is only tolerable when acted is not literature. Of these two, the former class is of more interest to us as students of literature than the latter, to which we need give no attention whatever. If we bear these points in mind there will be no need to enter into any minute explanations of the varying qualities of dramatic literature as we proceed with our study.

The Rise of the Drama. We turn now to what is our chief inheritance from the Elizabethan age—its dramatic poetry. Our drama might almost be said to have begun and ended in one great burst of glory; for if all that has been written since the last of the Elizabethans, with two or three exceptions, were to be wiped away, our dramatic literature would not be greatly impoverished. The evolution of the English drama is sometimes ascribed to the old "mysteries" invented by the mediæval clergy for the purpose of teaching the ignorant mob some smattering of Biblical knowledge, which crude representations of sacred history gave place gradually to the "morality" play, wherein the teachers of the people endeavoured to visualise before their dim intelligences the Christian virtues. From this it was but a step to the stage representation of the common life, and, as we have seen, that step had been taken before the reign of Elizabeth, Heywood's interludes forming a link between the morality play and the drama proper.

Early Dramatists. GEORGE GASCOIGNE (b. 1537; d. 1577) was one of the earliest dramatists and a poet of no mean place among the Elizabethans, his spirited satire, "The Steel Glass," being the longest and one of the most virile compositions in blank verse before Milton. But it is evident in his dramatic work that he was influenced not so much by the disappearing morality play as by the ancient classical drama, his "Jocasta" being an adaptation from the "Phœnissæ" of Euripides, while his "Comedy of Supposes," whence Shakespeare borrowed for his "Taming of the Shrew," was a prose translation of Ariosto's comedy, "Gli Suppositi." Indeed, it is hardly correct to speak of any "link" between the modern drama and the morality play, as in all countries the rise of the drama was the outcome of a revival of learning which led the writers to look back across the ages and to find their models in the ancient classical drama, the machinery of the stage, however, being ready to their hand as it existed for the purpose of the "moralities." The first regular comedy in our language, "Ralph Roister Doister," by NICHOLAS UDALL (b. 1506; d. 1556), Master of Eton, was modelled on the comedies of Plautus and Terence, while Sackville and Norton's "Gorboduc," our first regular tragedy, produced on 18th January, 1562, was modelled on the tragedies of Seneca.

Scholarship and Character. Comedy shaped itself into true dramatic form earlier than tragedy, and the art owed well-nigh as much to such writers as Greene and Peele as tragedy did to Marlowe. Most of the early dramatists were poet-scholars, men who had been educated at Oxford and Cambridge, and who, to their knowledge of classical models

added a racy intimacy with the life of the day, which enabled them, while observing the ancient ideas of dramatic construction, to appeal to the common people with subjects of living interest. In fact, these men of rare wit and scholarship were sadly too familiar with the life of their times, and their biographies, so far as we can ascertain them, are for the most part melancholy records of lives untimely sacrificed to debauchery; sometimes, as in the case of Greene, utterly at variance with the ethical standards of their writings. It is noteworthy that Shakespeare, the great king of them all, was almost the only one who had no university training, and, in the then accepted definition of scholar, could rank with few of his contemporaries. He, too, was among the lesser group who showed a better balanced character, and in his own life observed a standard of conduct which to-day would have made him a person of almost suburban manners.

Lyly, Peele, and Greene. We shall not endeavour to enter in any detail into a chronicle of the early drama, and shall deal with the artists rather than the art, and even so, with only a few of the more notable of the dramatists. Among these some mention must be made of JOHN LYLY (b. 1553 ; d. 1606), as his name is, for other reasons than his talent, conspicuous in the early Elizabethan period. He was not a dramatist of any great ability, his comedies in prose and verse being unworthy of attention to-day except from the close student of the Elizabethan drama. He had a lyrical rather than a dramatic gift, some of his songs in his plays being wholly delightful. We shall have occasion to consider his work in more detail when we come to deal with the origin of modern prose. GEORGE PEELE (b. about 1558 ; d. 1598) made more valuable contributions to comedy, though his plays are stronger in poetic fancy and form than they are in dramatic construction. His comedies, such as "The Arraignment of Paris," and "The Old Wives' Tale," are as pretty and engaging as his tragedies, such as "The Battle of Alcazar," are bombastic and preposterous. ROBERT GREENE (b. 1560 ; d. 1592) was a poet of very similar gifts to his boon companion Peele. A follower of Lyly as a novelist, the best of his genius is to be seen in the beautiful lyrics which are introduced in his prose romances and his plays. Perhaps the most noteworthy of his dramatic pieces is "Friar Bacon and Friar Bungay." While both Peele and Greene have no great interest for the general reader, any student desiring to familiarise himself with this period of our drama must neglect neither of these writers. Although not strictly in place, we cannot refrain from quoting some lines from Greene's "Farewell to Folly," as illustrative of his lyrical poetry:

"Sweete are the thoughts that savour of content,
The quiet mind is richer than a crowne:
Sweete are the nights in careless slumber spent,
The poore estate scornes Fortune's angry frowne:
Such sweete content, such mindes, such sleepe, such bliss,
Beggars enjoy, when princes oft doe miss."

Christopher Marlowe. The first great name, however, the real herald of the English drama, was CHRISTOPHER MARLOWE (b. 1564 ; d. 1593), one of the most melancholy figures in our literary history. Had not he fallen a victim to a vicious and irregular life at the early age of twenty-nine, he might, his splendid powers ripened and exercised with the restraint of maturer judgment, have stood no more than a step behind Shakespeare himself. Indeed, when Marlowe was killed in a wretched tavern brawl Shakespeare's dramatic genius was still in the bud, though both poets had been born in the same year. Marlowe was the son of a poor Canterbury shoemaker, and may have owed his education at Cambridge University to some wealthy relative. He graduated M.A. in his twenty-fourth year, but two or three years earlier he is supposed to have been in London intent on becoming a dramatist. Records of the production of his works are somewhat confused, none of the plays being printed in his lifetime. "Tamburlaine the Great," supposed to have been his first, though disfigured by much bombast and fustian, is alive with real drama, and its style is instinct with poetic feeling. His other chief works are "Doctor Faustus," "Edward II.," "The Jew of Malta," and "The Massacre at Paris." It is generally agreed that "Edward II." is the best historical play in our language after Shakespeare, and Charles Lamb is not unduly enthusiastic when he says, "the reluctant pangs of abdicating Royalty in Edward furnished hints which Shakespeare scarcely improved in his 'Richard II.,' and the death scene of Marlowe's king moves pity and terror beyond any scene, ancient or modern, with which I am acquainted."

Marlowe's "Doctor Faustus." His greatest work is "Doctor Faustus," founded on the legend of the German magician who, for twenty-four years of unrestrained life, sold himself to the devil both body and soul, which is also the theme of the greatest poem of modern times, Goethe's "Faust." "There is," says Hallam, "an awful melancholy about Marlowe's Mephistopheles, perhaps more impressive than the malignant mirth of that fiend in the renowned work of Goethe. But the fair form of Margaret is wanting; and Marlowe has hardly earned the credit of having breathed a few casual inspirations into a greater mind than his own." Neither of the other two productions we have named is worthy of the poet's undoubted genius, and perhaps the opinion of Thomas Warton, the erudite historian of English poetry, gives the best critical summary of Marlowe's work: "His tragedies manifest traces of a just dramatic conception; but they abound with tedious and uninteresting scenes, or with such extravagances as proceeds from a want of judgment, and those barbarous ideas of the times over which it was the peculiar gift of Shakespeare's genius alone

to triumph and to predominate." Marlowe's plays are now little read, but every reader with any pretension to literary culture should at least be conversant with his "*Doctor Faustus*" and "The Jew of Malta." His beautiful lyric, "The Passionate Shepherd to his Love," will be familiar to most readers.

William Shakespeare. If we were to shear away every name in English dramatic poetry but that of Shakespeare, we could still claim for it such pre-eminence, especially in tragedy—the highest form of drama—that not even the glorious art of Greece could be said to transcend it. Indeed, tragedy, which sprang from the worship of the god Dionysus, or Bacchus—the altar and the chorus of the pagan temple having their counterparts in the Greek theatre—and rose into supreme poetic form in the tragedies of Æschylus, Sophocles, and Euripides, may be said to have culminated in the works of Shakespeare: the four greatest tragedies in the world are "Hamlet," "Othello," "Macbeth," and "King Lear." But it is the unmatched glory of WILLIAM SHAKESPEARE (b. 1564; d. 1616) that he achieved the highest in both tragedy and comedy. As Coleridge points out very aptly, Plato, in his "Dialogue of the Banquet," had two thousand years before framed "a justification of our Shakespeare" when he argued that "it was the business of one and the same genius to excel in tragic and comic poetry, or that the tragic poet ought, at the same time, to contain within himself the powers of comedy." This in Plato was little short of prophetic, as it laid down a canon utterly opposed by all the ancient critics, and quite unsupported by any example from the Greek dramatists, to whom tragedy and comedy were incompatible elements, having but one quality in common—ideality. "Both were alike ideal," says Coleridge; "that is, the comedy of Aristophanes rose to as great a distance above the ludicrous of real life as the tragedy of Sophocles above its tragic events and passions; and it is in this one point of absolute ideality that the comedy of Shakespeare and the old comedy of Athens coincide. In this also alone did the Greek tragedy and comedy unite; in everything else they were exactly opposed to each other. Tragedy is poetry in its deepest earnest; comedy is poetry in unlimited jest." Thus we see at a glance why Shakespeare is in all the world of genius the most commanding figure; his the one intellect which, while comprehending all human passions and emotions, could equally express all.

Shakespeare's Characters. Of course, no one will expect of us anything so audacious as an effort to condense within a page or two a study of Shakespeare. Betterton, the first really great tragedian, at the end of his career, when performing Hamlet for the last time, said that he had seldom in fifty years, and with all his continuous study, discharged that role without finding in the character some new beauty to express which previously he had not noticed, and this not less in his last performance of it. If this be true of only one of the multitude of characters created by Shakespeare, one might devote a lifetime of study to his works, and leave them unexhausted at the end. Nay, many men of great and original talent have done so, and many more will follow in their steps. For Shakespeare and his writings are not to be regarded as a great author and a department of study, but as a life and a literature. So limitless is the literature which has grown around the name of Shakespeare in all the languages of European culture, that only a man of the ripest scholarship and linguistic attainments can hope ever to obtain more than a partial knowledge of this mighty genius. But that is in no way to deter the ordinary reader from entering upon the study and enjoyment of a series of works which, if one read no others, would furnish the mind with the very essence of intellectual joy, and make its owner a person of culture. It is not the least of Shakespeare's distinctions that he commands the devotion and lifelong service of the best scholars while he entertains the most ordinary reader and the common playgoer.

"The True Enchanter." Remembering our point of view, perhaps we cannot do better than commend Shakespeare in the memorable words of Washington Irving, written on his visit to Stratford-on-Avon:

"On returning to my inn, I could not but reflect on the singular gift of the poet; to be able thus to spread the magic of his mind over the very face of Nature; to give to things and places a charm and character not their own, and to turn this working-day world into a perfect fairyland. He is indeed the true enchanter, whose spell operates, not upon the senses, but upon the imagination and the heart. Under the wizard influence of Shakespeare I had been walking all day in a complete delusion. I had surveyed the landscape through a prism of poetry which tinged every object with the hues of the rainbow. I had been surrounded by fancied beings; with mere airy nothings, conjured up by poetic power, yet which, to me, had all the charm of reality. I had heard Jacques soliloquise beneath his oak; had beheld the fair Rosalind and her companion adventuring through the woodlands; and, above all, had been once more present in spirit with fat Jack Falstaff and his contemporaries, from the august Justice Shallow, down to the gentle Master Slender and the sweet Anne Page. Ten thousand honours and blessings on the bard who has thus gilded the dull realities of life with innocent illusions; who has spread exquisite and unbought pleasures in my chequered path, and beguiled my spirit in many a lonely hour with all the cordial and cheerful sympathies of social life!"

The Life of Shakespeare. Only in the most summary fashion can we hope to outline Shakespeare's work; nor is there need that we should do more, as the reader must familiarise himself with *every* poem and play from the master's pen, as well as with those in which his share of authorship is a matter of speculation, and with various works of biography and criticism relating to Shakespeare. Although it is often said that some half-dozen facts are all

that we possess with certainty of the poet's life, the untiring industry of biographers and critics, especially during last century, not only in England but in Germany and in France, has supplemented the few historical facts with so much inferential knowledge, that there is no difficulty in realising for ourselves an adequate conception of the man, and in understanding, to the best of our individual capacities, the poet.

Shakespeare's Education. We have mentioned that almost alone among the Elizabethan dramatists—if we discredit the theory of Jonson's training—Shakespeare was not a university scholar; but it is fair to suppose that he received his education at the free school of Stratford, being under fourteen years of age when his father, who had hitherto been prosperous and prominent in the public life of the town, fell upon evil times, and had to withdraw his son in order to put him to a trade. It has been thought that he was apprenticed to a butcher, though some critics, on the strength of the legal knowledge displayed in his works, have supposed him to have been for a time an attorney's clerk. But on similar grounds it might be argued that he had meant to be a gardener, or had thoughts of the ministry. He was not eighteen when he married Anne Hathaway, a yeoman's daughter, eight years older than himself; and three or four years later, now the father of three children, and a social failure in his native town, he came to London, where in 1592 we find him an actor and a rising playwright. It is in this year that Greene, in his "Groatsworth of Wit," jibes at him as a "rude groome," who "supposes he is as well able to bumbast out a blanke verse as the best of you"—the sneer of a practised dramatist at a younger and more promising member of his craft.

Chronology of the Plays. Shakespeare attained to no great distinction as an actor, but his connection with the stage brought him in the way of literary work in the shape of altering old plays, retouching the writings of other dramatists when the manager employing him desired to revive their plays. Playwrights were then in the habit of selling to the theatrical managers for a few pounds the entire copyright of their plays, and as actors thought it prejudicial to their interests that the plays should be published, only a few plays of the period, and these chiefly in unauthorised versions, were printed during the lifetime of their authors. None of those which Shakespeare revised could be "old," in the sense that now attaches to old plays, as the theatre itself was only in its infancy when Shakespeare was a young man, the first tragedy, "Gorboduc," as we have heard, having been written but three years before his birth. The chronology of his earlier dramatic works has undergone many changes at the hands of different critics, from Malone, in 1778, to Mr. Sidney Lee, in 1898, but there is no great difficulty in deciding upon the approximate order of the 37 plays attributed to him, or in distinguishing those of which he was only part author. As Mr. Lee observes, "the subject matter and metre both afford rough clues to the period in his career to which each play may be referred. In his early plays the spirit of comedy or tragedy appears in its simplicity; as his powers gradually matured he depicted life in its most complex involutions, and portrayed with masterly insight the subtle graduations of human sentiment and the mysterious workings of human passion. Comedy and tragedy are gradually blended, and his work finally developed a pathos such as could only come of ripe experience. Similarly, the metre undergoes emancipation from the hampering restraints of fixed rule, and becomes flexible enough to respond to every phase of human feeling." For this reason the works of Shakespeare are best read in something like chronological order.

Shakespeare's Early Poetry. It is well, therefore, not to begin with the plays, but with the two long narrative poems, "Venus and Adonis" and "The Rape of Lucrece," as the former, published in 1593, was almost certainly the first effort of Shakespeare's muse, and the latter, appearing in the succeeding year, did much to establish the fame of the young play-actor, whose name was becoming familiar to patrons of the theatre as an adapter of plays. These were the works which first won him renown among his contemporaries, and, apart from their great poetic beauty, they are interesting to us for that reason. They are elaborately classical both in matter and in manner, typical of what we know as the Pagan Renaissance, because the influence on the Elizabethans was, as we have noted, that of ancient Greece and Rome.

"Venus and Adonis" is almost lascivious in the warmth of its passion, the ardour with which the amorous goddess woos the young hunter being in perfect harmony with the Greek ideal, and it has been thought that in this Shakespeare was not above the desire to win the regard of the patron to whom he dedicated his work, the young Earl of Southampton, who was reputed of a somewhat amorous disposition. But the exuberant fancy of the poem, the sensuous beauty of its imagery, its rhythmic sweetness, all give it such distinction that the licence of its tone cannot be held to preclude it from anyone's reading.

"The Rape of Lucrece," which deals with the tragic story of the lawless passion of Tarquin's son for the wife of Collatinus, whose nāme was fragrant of all wifely devotion, was dedicated to the same patron, and was truly that "graver labour" which the poet promised in his dedication of the first work. It gives evidence of such maturity in its reflective passages, and so great an increase of art in its whole conception and construction, that there may be good reason for supposing "Venus and Adonis" to have been an effort of the poet's youth, and considerably earlier in execution than even the first of his attempts at play revising. At all events, these two poems, if read before we undertake the study of the plays, will help us the better to understand

the unfolding and blossoming of Shakespeare's genius.

The Order of Shakespearian Study. We may now set forth the names of the plays in their order, following Mr. Sidney Lee's arrangement, and marking with an asterisk (*) those of which Shakespeare was only part author :

1. EARLY DRAMATIC WORK.	
Love's Labour's Lost	1591
Two Gentlemen of Verona	1591
The Comedy of Errors	1592
Romeo and Juliet	1592
*Henry VI. (First Part)	1592
*Henry VI. (Second Part)	1592
*Henry VI. (Third Part)	1592
Richard III.	1593
Richard II.	1593
*Titus Andronicus	1593
The Merchant of Venice	1594
King John	1594
2. THE DEVELOPMENT OF DRAMATIC POWER.	
A Midsummer Night's Dream	1594-5
All's Well that Ends Well	1595
The Taming of the Shrew	1595
Henry IV. (First Part)	1597
Henry IV. (Second Part)	1597
The Merry Wives of Windsor	1597
Henry V.	1598
3. MATURITY OF GENIUS.	
Much Ado About Nothing	1599
As You Like It	1599
Twelfth Night	1600
Julius Cæsar	1601
Hamlet	1602
Troilus and Cressida	1603
4. THE HIGHEST THEMES OF TRAGEDY.	
Othello	1604
Measure for Measure	1604
Macbeth	1606
King Lear	1607
*Timon of Athens	1608
*Pericles	1608
Antony and Cleopatra	1608
Coriolanus	1609
5. THE LATEST PLAYS.	
Cymbeline	1610
A Winter's Tale	1611
The Tempest	1611
*Henry VIII.	——

In the Study and on the Stage. Now, we do not suggest that the student of Shakespeare is to procure himself a good edition of the plays and poems and read them through precisely in the order given above. But we are persuaded that it is well, so far as it may be practicable, to read Shakespeare with more regard to the chronological order of the plays than to their grouping as comedies, histories, and tragedies, which is so frequently followed in the popular editions of the poet. Many influences will condition the reading of the plays; especially theatrical representation, for we are strongly of opinion that no student of Shakespeare should miss any opportunity of seeing his plays performed on the stage by good companies, and there are few towns of any considerable size where such opportunities do not occur frequently. Shakespeare is a poet for the stage *and* the study, and those who tell us they can enjoy him in the study but not on the stage do him an injustice and themselves no credit, as they should be able to enjoy him equally in both places. It will sometimes happen that the reader may have an opportunity of seeing a Shakespearian play which he has not read, and which, if he were following the above order of reading, he would not be likely to read for some time. The opportunity must not be lost, more especially if it be to witness one of the plays, such as "Cymbeline" or "Coriolanus," less frequently staged than others. The play should be read *before* seeing the theatrical representation of it, and again immediately afterwards. We feel sure that anyone following this course will be struck by the revelation of the subtler passages which results from witnessing a play, already familiar by reading, in its natural atmosphere of the stage. It was said of a great tragedian that to see him act was like reading Shakespeare by flashes of lightning. The phrase was not quite happy, as it is not well to read anything by lightning flashes. But what the critic meant was true: that the actor often interprets passages of the poet, which thus become illumined as by a flash of bright light, to the student, who may have missed their significance when reading the play.

How to Study one of Shakespeare's Plays. In most of the innumerable popular editions of Shakespeare's plays no hint whatever is given as to the sources whence the poet derived his subjects—sometimes, indeed, his very thoughts and words. But no thorough understanding of Shakespeare can be arrived at without this data, and the student is strongly recommended to study Shakespeare in some of those editions which give each play in a separate volume, with an introduction and notes by a competent scholar, and in some cases the full text of the original stories from which the poet has drawn the foundations of his work. There are so many of these editions to be had at low prices that we need not specify any particular one.

It is only in this way that a true critical estimate of the dramatist may be formed ; but at the same time we are not to place ourselves unreservedly in the hands of the critics and commentators, as it is always better, no matter how we may blunder in the first instance, to come by our own opinions in our reading, through the exercise of our own intelligence. What we have found out for ourselves is of far more value to us and the development of our mind than what we have received without question from a teacher. Obviously, in the case of Shakespearian study, we must accept a vast amount from the expositors of his text, but in doing so we can at the same time cultivate our own critical faculty by pursuing a course which will bring that into action ; and to this end we cannot do better than read a play for the first time in an edition which is not annotated. In

this way we are forced to form some independent judgment, and it is not of the slightest importance to the end in view whether that judgment be sound or ridiculous; the effort has been made, and only thus shall we ever attain to critical aptitude. After we have received our own personal impressions of the poet's appeal to our understanding, and formed our own blundering opinions of his work, we can, with far more profit to ourselves, place ourselves in the hands of a scholarly editor, whose notes, elucidations, and parallel quotations, will enable us to shape in our own mind an adequate conception of the poet's work, from which will be eliminated the mistaken notions formed in our first unguided reading, but in which will be retained the tested results of independent judgment. We need hardly observe that this method of reading is not limited in its application to the study of Shakespeare, though it is better adapted to the study of the dramatists and the poets generally than to the writers of prose.

"Shakespeare's Sonnets." Shakespeare's mind, and therethrough his life, can best be understood by following the sequence of his works. His "Sonnets" should be read with the plays of his second period, as most of them were written in the year 1594, though the collection was not published until 1609. Extraordinary interest has centred in this, the only other important work of Shakespeare's pen, and a whole library of books has been devoted to the discussion of the "mystery of the sonnets." We are unable to touch at any length on the subject, nor do we deem it at all essential, as we are persuaded that Mr. Sidney Lee, by the rare intelligence and precision of his critical method, has disposed of all the popular and fantastic theories of these poems. His conclusions go rather to support the late Professor Minto's theory as to their being written to show Shakespeare's contempt for the extravagant vogue of the sonnet among his contemporaries, than to further any of the other popularly accepted notions of their origin. If not written as a *tour de force*, then they were no more than an experiment in the fashion of the hour, and the profound autobiographical value many have supposed them to possess is largely imaginary. Some of them were indited to the poet's patron, the Earl of Southampton; many have no relationship whatever to any others in the collection, and the common idea that sonnets 1 to 126 are "addressed to a beautiful young man of high station," and 127 to 154 "either addressed to or referring to a married woman of dark complexion, highly accomplished, fascinating, but of irregular conduct," is no longer tenable in the light of Mr. Lee's researches.

Biographical Value of the Sonnets. In summing up his conclusions as to the biographical value of Shakespeare's sonnets, Mr. Lee writes: "A personal note may have escaped him involuntarily in the sonnets in which he gives voice to a sense of melancholy and self-remorse, but his dramatic instinct never slept, and there is no proof that he is doing more in those sonnets than producing dramatically the illusion of a personal confession. Only in one scattered series of six sonnets, where he introduced a topic, unknown to other sonneteers, of a lover's supersession by his friend in a mistress's graces, does he seem to show independence of his comrades and draw directly on an incident in his own life, but even there the emotion is wanting in seriousness. The sole biographical inference deducible from the 'Sonnets' is that at one time in his career Shakespeare disdained no weapon of flattery in an endeavour to monopolise the bountiful patronage of a young man of rank. External evidence agrees with internal evidence in identifying the belauded patron with the Earl of Southampton, and the real value to a biographer of Shakespeare's 'Sonnets' is the corroboration they give of the ancient tradition that the Earl of Southampton, to whom his two narrative poems were openly dedicated, gave Shakespeare, at an early period of his literary career, help and encouragement."

Books on Shakespeare. As we have already hinted, we are making no effort in our treatment of Shakespeare to do more than throw out a few practical hints which, having proved of value in our own case, cannot fail to be useful to others. Anything approaching an adequate survey of his work is so far beyond the scope of this course that even to attempt it briefly would be as unwise as it would be unnecessary, since it is imperative that the reader must familiarise himself with every line which Shakespeare has written, together with the best that has been written about him, and at the end of this section we give a list of such works recommended for study. Here we would make special mention of two. For the beginner we do not know a better little handbook than Professor Dowden's "Introduction to Shakespeare" (Blackie, 2s. 6d.). This, however, is only for the beginner; as the student progresses he will require a work of a more comprehensive kind, and nothing in modern criticism of Shakespeare excels "A Life of William Shakespeare" (Smith, Elder, 7s. 6d.), by Mr. Sidney Lee.

It only remains to add, in pursuance of our biographical method, that the tale of Shakespeare's work from 1592 until his final retirement to Stratford, in 1611, supplies most that we know of his life. He had become part-owner of the Globe Theatre, the leading London playhouse, in 1599. His income, which in his later years must have been about £600 per annum in the money of the time, was derived chiefly from his share in this theatre. Two years earlier he had purchased New Place, the largest house in Stratford-upon-Avon, where he died, on April 23rd, 1616.

Continued

Group 12
MECHANICAL ENGINEERING
5
Continued from page 545

ELEMENTS OF MACHINES

Being a Study of the Principles of Several Types of Levers: Wheels and Axles, Pulleys, Inclined Planes, Wedges and Screws

By JOSEPH G. HORNER

A MACHINE, no matter of what nature or how complicated it may be, is an instrument by which force applied at one point is transferred to another point, being at the same time intensified or changed in direction. This modified force has always to overcome some resistance, as that of gravity, friction, or the cohesion of particles of matter. This resistance in mechanics is denoted by the term *weight* (W), and the force applied to overcome it is termed *power* (P). In statics, the problem is to find the magnitude of P acting at one point necessary to balance W at another point; it is generally supposed, however, that P is sufficient to set a machine in motion. When the weight (W) is greater than the power (P), the machine is said to work at a *mechanical advantage*, the ratio being shown by the fraction $\frac{W}{P}$. But if this fraction is not greater than unity—that is, if W is less than P in magnitude—the machine works at a *mechanical disadvantage.*

The elements of the most complex machine are reducible to what are called the *six mechanical powers:* (1) the lever; (2) the wheel and axle; (3) the pulley; (4) the inclined plane; (5) the wedge; (6) the screw.

A *lever* is a rigid rod free to turn about a fixed point called the *fulcrum.* Levers are divided into three classes according to the relative positions of the power, fulcrum, and weight. Thus they may be placed in the order PFW, PWF, or WPF [58-60]. The condition for equilibrium in a lever of any of these three classes is that the movement [Fig. 30, page 413] of the power round the fulcrum be equal and opposite to that of the weight. Therefore P, multiplied by its arm (AC) = W, multiplied by its arm (BC). That is, $\frac{W}{P} = \frac{AC}{BC}$.

Levers of the First Class [58]. Remembering what has been said above concerning mechanical advantage, it is clear that levers of this first group will be only mechanically advantageous when AC is greater than BC, so that the fraction shall be greater than unity. If the arm BC is longer than AC, the lever will be mechanically disadvantageous, the effort being greater than the weight required to be raised. The effort will be equal to the weight when AC = BC, and the fraction equals unity. Common examples of the first class of lever are the poker, the handle of a pump, see-saw, crowbar (when it rests on a block in front of the weight being raised), and a canal lock-gate Scissors form a double lever of the first class.

Levers of the Second Class [59]. Here AC is always greater than BC, and there is, therefore, always a mechanical advantage. The crowbar—when one end rests on the ground—and the wheelbarrow are everyday examples of levers of the second class. Nutcrackers are a double lever of this type.

Levers of the Third Class [60]. In this class, AC is always less than BC, which means that $\frac{AC}{BC}$, or $\frac{W}{P}$ is less than unity, and so levers of the third class are always disadvantageous as regards power. Nevertheless, they are useful where speed and range of movement are required. For example, if ACW [61] represent a man's arm bent at the elbow, the hand holding a weight (W), it is evident that the contraction of the muscle through the small arc at P will cause the weight to move through the relatively much greater arc shown by the dotted line from W. A fishing-rod, the treadle of a turning-lathe, a whip, and the fore-arm as mentioned above, are all levers of the third class, tongs being a double lever of the same kind.

Wheel and Axle. The second mechanical power, *the wheel and axle*, is merely a modification of the lever. It consists [62] of two cylinders turning on a common axis. The larger cylinder is conventionally called the wheel, the smaller one the axle. Ropes are coiled round both wheel and axle, but in opposite directions, so that as the rope round one unwinds, that round the other winds up. Looking at the end section in the illustration, the principle of the lever will be immediately observed. The power and the weight act at the points A and B, where for the moment the two ropes are tangents to the two circles, and the conditions for equilibrium for the ordinary lever hold good in the wheel and axle—namely, $P \times AC = W \times BC$; or $\frac{W}{P} = \frac{AC}{BC}$; *i.e.,* $\frac{W}{P} = \frac{\text{Radius of wheel}}{\text{Radius of axle}}$, and since the circumference of a circle is proportional to its radius, the conditions of equilibrium are reduced to $\frac{W}{P} = \frac{\text{Circum. of wheel}}{\text{Circum. of axle}}$. From which it follows that a big wheel and a small axle will give greater mechanical advantage than when the diameters more nearly approach each other. The capstan, windlass, rack and pinion, and toothed wheels in general, are common examples of the principle of the lever, or wheel and axle.

Pulleys. The *pulley* is a wheel whose circumference is grooved to prevent the rope —called the tackle—which passes round it from slipping off the wheel turns freely on an axis through its centre, and is fixed in a framework called the pulley-block, or sheave. Sometimes this pulley-block is fixed to a

beam, or rafter for example; sometimes it is movable, as on a crane, and sometimes a series of pulleys are arranged in a particular combination.

The *fixed pulley* [63] gives no mechanical advantage, the weight on one string requiring to be balanced by an equal weight on the other. It is useful, however, in changing the direction of a force, so that by pulling down, or horizontally, a weight may be raised vertically.

Movable Pulleys. The single *movable pulley* is shown in 64. The weight (W) being supported by two cords, the tension on each is evidently $\frac{1}{2}$ W, but as one cord is attached at A to the beam, the force or weight P has only to support $\frac{1}{2}$ W, or $\frac{W}{2}$. Thus $P = \frac{W}{2}$: *i.e.*, $\frac{W}{P} = 2$, or the mechanical advantage in a single movable pulley $= 2$. In other words, the weight is twice the power—1 lb. being able to support 2 lb. To obtain this advantage, however, the strings must be parallel.

A still greater advantage is gained when several movable pulleys are combined to raise a weight. The three methods of combining movable pulleys are spoken of as the first, second, and third systems.

Separate-string System. In the first, or separate-string system [65] each pulley hangs by a separate cord; one end is fastened to a beam or other support, and after passing round a pulley the cord is attached to the block of the one above it; the last cord, however, passes round the fixed pulley and supports the counterpoise (P), the weight (W) being attached to the lowest pulley.

It is necessary to suppose in all theoretical questions concerning pulleys that the ropes or cords are perfectly flexible and that friction is absent. Then it follows that *the tension of the rope is the same in every part* irrespective of the number of pulleys in the combination. As a matter of fact, however, these two theoretical conditions are very far from being present in practical work, and though in theory the greater the number of pulleys in any system the greater would be the mechanical advantage, the enormous amount of friction and the lack of flexibility of cord render a multiplication of pulleys impossible.

In 65 it is clear that the tensions on the strings marked 1 are equal, as in the case of the single movable pulley, so that P supports a weight equal to 2P on the first pulley-block (A). Hence the tension on the string below A equals 2P, and so the pulley B supports a weight 4P (2^2P). In the same way C supports a weight 8P (2^3P), and so on, each successive block doubling the mechanical advantage. With three pulleys, therefore, $W = 2^3P$; with four pulleys, $W = 2^4P$; with any number of pulleys conveniently represented by the letter *n*, $W = 2^nP$, *i.e.*, $\frac{W}{P} = 2^n$. Thus the mechanical advantage in the first system $= 2^n$.

Single-string System. In the second, or *single-string system* [66] the pulleys are contained in two blocks, the upper one fixed, the lower one movable, the weight being attached to the latter. The same string passes round all the pulleys as shown in the diagram. Here the tension throughout the string equals P, and as there are four (practically) vertical strings supporting the lower block, the weight W is supported by four upward forces, each equal to P. Therefore $W = 4P$. If there are *n* pulleys, then $W = nP$; *i.e.*, $\frac{W}{P} = n$. Thus the mechanical advantage in the second system $= n$.

The Third System. The third system is really the first system turned upside down, as in 67, the end of each string being attached to a bar carrying the weight. The tensions supporting the weight here are $P + 2P + 4P$. Thus $W = 7P$, or $W = (2^3 - 1)P$, the index of the figure 2 representing the number of pulleys. With four pulleys $W = (2^4 - 1)P = (16 - 1)P = 15P$. With *n* pulleys, $W = (2^n - 1)P$: *i.e.*, $\frac{W}{P} = 2^n - 1$. Thus the mechanical advantage in the third system $= 2^n - 1$. It must be noted, however, that in this system the weights of the pulleys assist the power instead of acting against it, as in the other two systems.

The Inclined Plane. The inclined plane permits of the raising of a body to a particular height by exerting a smaller force through a greater distance. The directions in which a force may be applied to a body on an inclined plane are: (1) *horizontally*; (2) *parallel to the plane*.

In 68, which represents a section of an inclined plane, the force acts parallel to the plane. Three forces combine to keep the body in equilibrium: (1) the weight (W) acting vertically downwards; (2) the reaction or resistance (R) of the plane acting perpendicularly to the plane; (3) the pull or power (P) acting up the plane. (The surface of an inclined plane is theoretically perfectly smooth and free from friction, and by the reaction (R) is meant the resistance of the plane to bending, breaking, or penetration. Hence the force R acts perpendicularly to the surface.) It can then be shown by the Triangle of Forces that $\frac{P}{BC} = \frac{R}{AC} = \frac{W}{AB}$. That is, $\frac{P}{\text{Height of plane}} = \frac{R}{\text{Base of plane}} = \frac{W}{\text{Length of plane}}$. Therefore the pull required may be found from the equation $P = W \times \frac{\text{Height of plane}}{\text{Length of plane}}$, and the resistance $R = W \times \frac{\text{Base of plane}}{\text{Length of plane}}$. The mechanical advantage of the inclined plane $= \frac{W}{P} = \frac{\text{Length}}{\text{Height}}$; in other words, the greater the incline in a road or railway the greater is the pull required.

Pulls and Gradients. On a gradient of 3 in 10 a weight of 160 lb. could be pulled by a force slightly greater than 48 lb. If, however, the gradient were but 3 in 16 the force necessary

would be scarcely more than 30 lb. The weight would therefore be raised to the same height with a less force; but it must be remembered that as this force acts through a greater distance no work is saved. Whatever be the gradient, the work done by P acting along the plane is always equal to the work which would be done in raising the load W vertically from C to B. That is, $P \times AB = W \times BC$, or, as we have just seen,

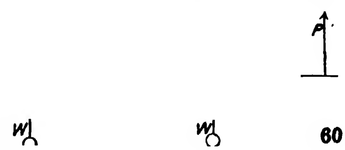
$$\frac{W}{P} = \frac{AB}{BC} = \frac{\text{Length}}{\text{Height}}.$$

When the force is applied horizontally, as in **69**, then the ratio between the forces keeping the body in equilibrium is $\frac{P}{\text{Height of plane}} = \frac{R}{\text{Length of plane}} = \frac{W}{\text{Base of plane}}$. Then $P = W \times \frac{\text{Height of plane}}{\text{Base of plane}}$, and the resistance,

penetrating instruments. A wedge whose section is an isosceles triangle is the commonest and most advantageous form. The force is applied at the back of the wedge (AB), and the resistance on each side may be considered to act at right angles to the slant edges of the wedge.

Owing to the fact that the power applied to AB is not a continued pressure but a series of impulsive forces, the theory of the wedge is less exact than that of the other mechanical powers. Considering the power and the resistance on each side, however, as three forces in equilibrium, it may be demonstrated that the resistance $R = P \times \frac{\text{Length of equal side}}{\text{Back of wedge}}$.

Then the mechanical advantage will be $\frac{R}{P} = \frac{\text{Length of equal side}}{\text{Back of wedge}}$. So that by diminishing the size of the back and increasing the length of



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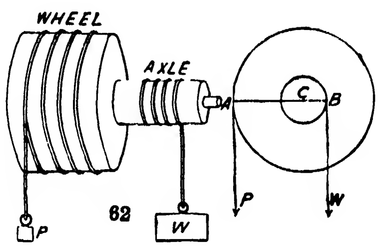

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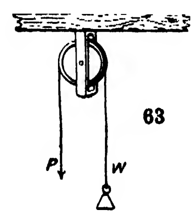


63

APPLICATIONS OF MECHANICAL POWER

$R = W \times \frac{\text{Length of plane}}{\text{Base of plane}}$. Also $\frac{W}{P} = \frac{\text{Base}}{\text{Height}}$. Considering this second case from the point of view of work done, since P acts in the direction AC, then $P \times AC$ = work done by P. Also the work done by raising the load W vertically through $CB = W \times BC$. And $P \times AC = W \times BC$; *i.e.*, $\frac{W}{P} = \frac{AC}{BC} = \frac{\text{Base}}{\text{Height}}$. Again, in **68**, since each force is proportional to the side to which it is perpendicular—*i.e.*, P, R, W are proportional to the height, base, and length respectively—and since $AB^2 = AC^2 + BC^2$ (Euc. I. 47), therefore $W^2 = P^2 + R^2$. In the case where the force applied is horizontal, $AC^2 = AB^2 - BC^2$; that is, $W^2 = R^2 - P^2$.

The Wedge. The *wedge* [**70**] is a block tapering to a thin edge, a double inclined plane as it were. It is used for splitting wood or other material, and for raising heavy bodies, as in the raising of a ship in a dry dock by inserting wedges under the keel. Common examples of wedges are knives, chisels, swords, axes, plugs, planes, needles and pins, nails, and all cutting and

the side—that is, diminishing the angle of penetration—the mechanical power of the wedge is increased.

The Screw. The *screw* is the last of the mechanical powers, and, like the wedge, is derived from the inclined plane. It consists of a cylinder, on whose surface is a spiral ridge called the *thread*. The relation between the thread and the inclined plane is easily seen by cutting out a right-angled triangle of paper, corresponding to the section of an inclined plane. If this be wrapped round a rod—say, a round ruler—the hypotenuse of the triangle forms the screw thread, or *helix*, the base of the triangle (or plane) corresponds with the circumference of the cylinder, and the height will be the distance between the threads, or the *step* of the screw, technically known as the *pitch*. The threads are sometimes square in section (square screws), sometimes acute (sharp or vee screws). The screw works in a fixed *collar* or *nut*, which is a hollow cylinder, whose internal surface carries a groove, or internal thread, in which the screw thread fits.

The ordinary copying-press illustrates the method of using the screw. Power is applied by means of a lever (the arm or handle of the press) attached to the end of the screw. The screw then moves forward in the direction of its axis, overcoming resistance. Or, as in the case of the screw-jack, it may be used to raise a weight.

In finding the relation between the force applied and the resistance which is overcome, it is important to note that every time the screw performs a complete revolution it moves forward through a distance equal to the space between one thread and the next. If, in **71**, power (P) be applied so that the arm *b* makes a complete revolution, the work done will be equal to P multiplied by the circumference of the circle of which *b* is the radius—that is, $P \times 2\pi b$. At the same time, the work (W) done by the screw in moving through the distance P (the space between two threads) equals $W \times P$. Then $P \times 2\pi b = W \times P$. And the mechanical advantage is:

$$\frac{W}{P} = \frac{2\pi b}{P} = \frac{\text{Circum. of circle described by lever}}{\text{Pitch, or step, of the screw}}.$$

Thus the mechanical advantage is increased by diminishing the pitch, or by increasing the length of the arm or lever to which the power is applied.

We recognise in the levers examples of the turning pairs of Reuleaux; in the inclined plane and wedge, sliding pairs; and in the screw, twisting pairs, or a movement of translation in a helical plane around an axis. The lever and the inclined plane, therefore, include all essential mechanical motions, no matter how they are disguised in a thousand-and-one mechanisms. Only when first principles are thus grasped is it possible to analyse machines and avoid error in classification. There have been thousands of useless patents taken out that never would have been applied for if the patentees had possessed an elementary knowledge of mechanics.

Constraint. If we now look further into these examples, we find that the feature of constraint is an essential one. The elements are all paired together in such a way that they can only move in certain relations, and each pair of elements is paired with others adjacent, so that the movements of each are under constraint. The elements themselves Reuleaux termed *links*, or *kinematic links*, and the whole series of adjacent elements, *closed kinematic chains*. As no element in a mechanism can move without reference to all the others, that is a fundamental conception of a machine, and the workability of a mechanism can always be tested by this simple proposition. In the preceding figures it is easy to see that the introduction of some one element into the chain of moving elements would interfere with their proper operation.

In the levers the fulcrum must be fixed and incapable of movement, and the arms must be free to turn around the fulcrum as a centre. In the wheel-and-pulley systems the centres of certain pulleys are fixed, others are movable. The movement of the "cord" is constrained to one direction. The sliding movements of the load on an inclined plane; that of the wedge, and that of a nut in its screw, are also constrained. In fact, it would be impossible to conceive of a mechanism from which the condition should be absent.

But in speaking of kinematic links and chains we must not be understood to use the term in its literal sense. Links are often non-rigid. A cord, a belt, a spring, or even a pressure fluid, as water, gas, steam, is as truly a link as a bar of steel is. All depends on its application and its relation to other rigid parts. Tension and compression elements are alike links. By the use of springs, for example, a mechanism is often prevented from knocking itself to pieces. Yet the movements of the mechanism are as surely accomplished under the constraint of the elastic spring as though it were a non-elastic bar. So with the cords, ropes, chains, or pulley systems. Flexibility is essential, yet the connections and the relative movements are assured.

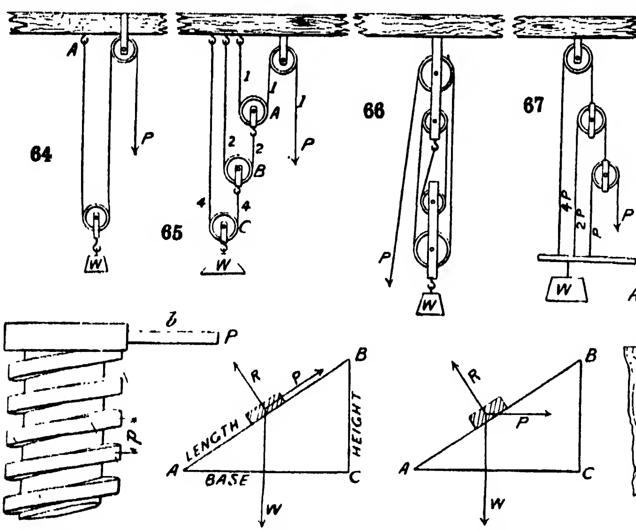
Applications of Power in Practice. Going a stage further, the engineer sees in these diagrams only the skeleton outlines which denote principles. Looking beyond them he recognises a hundred mechanisms which clothe the bare anatomy with living forms. The fulcrum in the lever group does actually occur in the triangular form shown, in the knife edges of weighbridges and balances. But most often it is the cylindrical pivot of a beam or a rocking lever, or of a derricking crane-jib, or the crank-pin of an engine, or the shafts of wheels. The gaunt lines become disguised in the strong arms and ribs of pulleys, of toothed wheels, of engine-beams. The crude wheel and axle appear in some pulley-block designs, but the "axle" much more often occurs in the disguised form of the chain-drums of cranes; while the "wheel" is recognisable in the winch-handle, or the large driving wheel on the drum-shaft. The fixed pulley is found at the head of all crane-jibs, and elsewhere. Movable pulleys occur in pulley-blocks of divers forms, arranged in more workable designs than those used for diagram purposes, while the friction which is so excessive in these is turned to account in the self-sustaining or differential type. The inclined plane is utilised in keel-blocks for ships, in inclined tracks for mines, and for heaving up slips for vessels. The wedge appears in various forms of friction clutches for the driving and release of shafting, in cottars and keys for uniting lengths of rod, and fastening wheels to shafts, and generally for making metal connections that can be rapidly made and broken.

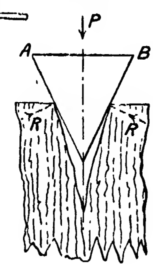
The inclined plane in the form of the screw is perhaps used to a larger extent than any other single element of mechanism. It becomes a means of connection and union, temporary or permanent, a device for producing end-long movement, a mechanism in combination with the lever for gaining almost unlimited power, a device for imparting linear movement to

materials, as in conveyors, a method of measurement, the agent for the propulsion of the biggest liners and battleships.

Over and over again mechanisms are so changed that their essential elements are disguised. The relation between the two-bladed propeller and the carpenter's wood screw is fairly obvious. But everyone would not identify the herringbone form of tooth gear with a screw, nor either with the worm-wheel Yet the relations are readily demonstrable.

The Test of Practicability. The enormous loss of power and of time in some mechanisms explains why these are not used to any great extent. Neither of the pulley arrangements shown, excepting the first two, are used much in hoisting machinery, because the speed is far too slow, and the height of lift too limited. Hence the lever, in the disguise of trains of toothed gears, is employed by preference for the gain of power, so separating the mechanism for mechanical advantage from that for mere lifting. Almost the only variety employed is that shown in **64**, where the common snatch block will be recognised. The differential block is based on **66**, though not in that form.





APPLICATIONS OF MECHANICAL POWER

If the screw is combined with a lever the power gained is enormous, but the movement is too slow for common mechanisms unless a high initial rate of movement is imparted to the lever (in such cases a shaft, or pulley, or motor) driving it.

Often the speed is of no consequence, but the screw is utilised as a precision mechanism, as in dividing-gears, and in the lead screws of lathes, in which the pitch of the threads is the first factor in effecting divisions mechanically.

Fundamental Distinction between Screws. A volume might be written on this single aspect of the screw, that of an instrument for dividing and measuring. It is used for these functions in every engineer's shop in the world, and also in the finest dividing instruments made for astronomical and scientific purposes. From the time of Maudslay to the present moment mechanicians have been constantly striving to get as nearly as practicable to a perfect screw. Recently, a Standard Leading Screw Adjusting Machine has been fitted at the National Physical Laboratory, in which the average limit of error in the screw does not exceed 0·00018 in. per foot of length. To obtain such remarkable accuracy common workshop methods fail, since the effects of change of temperature have to be guarded against; the means of support, of measurement, of cutting and correcting, have all to be devised, and applied to the one task of securing accuracy regardless of cost.

There is a great and fundamental distinction between screws. One kind, the lead-screw, is used as a master for cutting other screws by, traversing a heavy tool carriage as part of their work, as in screw-cutting lathes, and is, therefore, constantly wearing; the other is employed for division only, and is subject to practically no wear and friction, as in the dividing engines and micrometer instruments. In the latter, of which the famous Whitworth measuring machine was the prototype, the pitch of the screw itself is subdivided by a large disc (constituting a nut), and finely graduated around its periphery. One complete rotation of the disc moves the screw a distance equal to the pitch, half a turn half the pitch, and all smaller movements accordingly, these being indicated by the arc divisions on the circular periphery. In commercial machines of this kind dimensions of $\frac{1}{100000}$ part of an inch can be detected.

A number of practical applications of the foregoing will be reserved for the next article—a small selection only. The farther the student strays into the realm of mechanics the farther do its vistas seem to extend.

Applications of first principles appear in unexpected forms; analogies and problems arise to exercise the mind. There is never any slackening of interest in these things. Life is too brief and time too precious to the student to be wasted in trivialities.

Continued

SHORTHAND

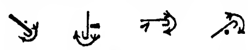
Fifth Instalment of the Special Course of Shorthand Taught by Messrs. Pitman & Sons on their Twentieth Century Plan

Continued from page 588

By SIR ISAAC PITMAN & SONS

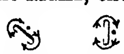
IN this lesson we deal with the hooks placed at the end of consonants, and hence termed final hooks; these are easily mastered, and complete the hooking system of Pitman's Shorthand.

Final N and F Hooks. A small final hook, struck by the RIGHT or forward motion adds *n* to straight consonants; thus



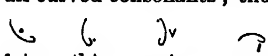
Ben, tone, coin, rain.

It will be noticed that the hook which represents *r* at the beginning of a straight consonant, and that which represents *n* at the end are both struck towards the RIGHT, thus



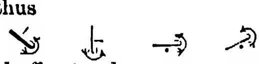
brain, train.

A small final hook, written inside the curves, adds *n* to all curved consonants; thus



fain, thin, assign, moon.

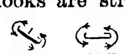
A small final hook, struck by the LEFT or backward motion, adds *f* or *v* to straight consonants; thus



buff, tough, cave, rave.

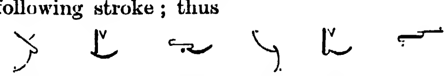
There is no *f* or *v* hook to curves.

The hook which represents *l* at the beginning of a straight consonant represents *f* or *v* at the end, and both hooks are struck towards the LEFT; thus



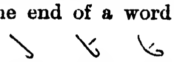
bluff, cliff.

The *n* and *f* hooks may be employed medially when they join easily and clearly with the following stroke; thus



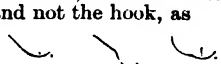
punish, dining, cleaning, fancy, diving, graphic.

A hook at the end of a word is always read LAST; as



pen, puff, fun;

therefore, when a word ends with *n*, or *f* or *v*, followed by a vowel, the stroke consonant must be written and not the hook, as



penny, puffy, funny.

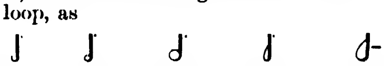
The forms *shl*, *shn*, when written upward, and *ln*, when written downward, must never stand ALONE, because it might be supposed that they had been written downward, and upward. These forms are distinct when joined to others; as

official, valuation, fallen.

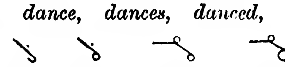
EXERCISE.

1 Ten, John, bun, ozone, Dane, then, plain, drain.
2 Doff, Jeff, pave, chough, Duff, hoof, brave, proof.
3 Wean, weave, wine, woof, run, roof, turn, turf.
4 Fen, fenny, Avon, venue, mine, Minnie, nun, ninny.
5 Banish, plenty, ORganic, mechanic, paving, cuff, coffee.
6 David, gun, agony, martial, traveL, chiefLy, aniLine.

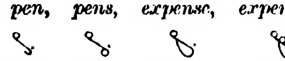
Circles and Loops added to Final Hooks. A circle or loop is added to the hook *n* attached to a straight consonant by writing the circle or loop *on the same side* as the hook, and thus turning the hook into a circle or loop, as



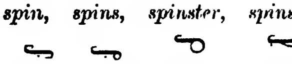
Dan, dance, dances, danced, Dunster;



pen, pens, expense, expenses;



spin, spins, spinster, spinsters;



glen, glens, glances, glanced.

The circle represents *s* only between two consonants, thus is not *pms-m* but *p-s-m*, as in the word *opossum*. Therefore, when *ns* occurs medially both letters must be shown, as

ransom, density.

The circle *s* is added to the hook *n* attached to curved consonants and to the hook *f* attached to straight consonants by writing the circle inside the hook; thus

fine, fines, frowns: puffs, drives, grieves, weaves.

In order to distinguish between *nz* and *ns*, etc., after a *curved* consonant, as in *vans(z)* and *Vance(s)*, the stroke *n* must be used for *anse, ense, inse,* or *ance, ence, ince,* thus
but but
vans Vance; men's(z) mince(s).

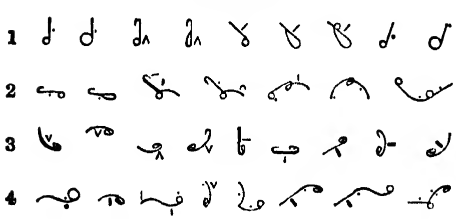
This distinction does not apply to *l* when coming *after another consonant*, and the hook is used in such outlines for *ns;* thus

balance.

The large circle *ses* and the loop *st* and *str* cannot be written inside the small *n* and *f* hooks; therefore, *nsez, nst,* and *nster*, following a *curved* consonant, must be expressed by the stroke *n* with the large circle or loop attached; thus

fences, fenced.

EXERCISE.



1 Pins, spoons, bounced, brains, tuns, trains, grains.

2 Jones, dunce, dunces, pounce, pounces, winsome.

3 Fens, offence, lens, lance, nines, ninnies, derives, Buffs.

4 Prudence, opulence, summons, science, lines, violence.

Final -*TION* Hook. The termination *-tion*, also variously written *-cion, -cian, -tian, -sian*, etc., is expressed by a large final hook; thus

edition, fashion, mission, caution, Persian.

The circle *s* is added thus

nations, additions.

When *-tion* hook follows a curved consonant it is written inside the curve, like the final *n* hook, thus

fusion, vision, session, motion, notion.

When *-tion* follows a simple straight consonant, the hook is written on the side opposite to the LAST vowel; thus

passion, option, occasion, auction,

diction, education, aberration, duration.

When *-tion* follows a straight letter which begins with a hook, circle, or loop, or springs from the curves [up] the *-tion* hook is written on the opposite side, to preserve the straightness of the letter; thus

abrasion, repletion, attrition, citation,

Grecian, section, affection, location.

After *t, d,* or *j*, not beginning with a hook, circle, or loop, the *-tion* hook is written on the RIGHT side, irrespective of the vowel; thus

dictation, rotation, degradation, magician.

The *-tion* hook is used medially, as

additional, dictionary, auctioneer,

cautionary, devotional, national.

When *-tion* follows the circle *s* or *ns*, it is expressed by continuing the circle on the other side of the consonant so as to form a small hook; thus Second-place dot vowels between the circle and *-tion* are written OUTSIDE the hook; third-place vowels are written INSIDE the hook; thus

possession, position, musician, accession, sensation,

incision, authorization, dispensation, transition.

First-place vowels do not occur between *s* and the syllable *-tion*.

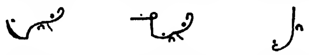
The circle *s* may be added to this hook; thus

positions, *suppositions*, *musicians*;

and the hook may be used medially; thus

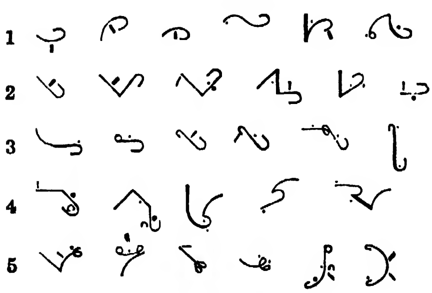
positional, *transitional*.

When two distinct vowel signs occur immediately before *-tion*, write *sh* and the hook *n*, in order to accommodate the vowel signs; thus



valuation, *extenuation*, *tuition*.

EXERCISE.



EXERCISE.

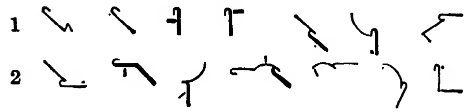
1 Ovation, omission, illusion; lotions, orations, sessions.
2 Potion, cushion, ration, apparition, elocution.
3 Expression, fiction, navigation; Prussians, accretions.
4 Tactician, adaptation, cogitation; notions, imitations.
5 Cremation, salvation, remission; donations, collisions.
6 Exceptional, occasional, sessional, missionary.
7 Cessation, precision, vexation; annexations, pulsations.
8 Accessional, recessional; superannuation (*shn* up).

Grammalogues. At this stage the following additional grammalogues should be memorized.

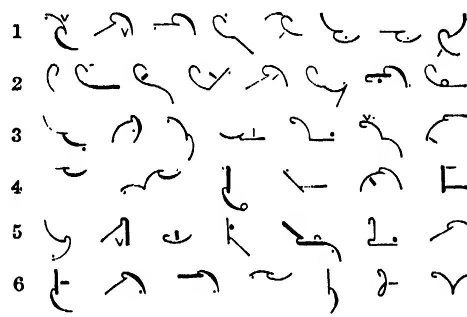
call (¹)	*more*, or *re-mark-ed* (¹)	*their*, or *there*
care	*Mr*, or *mere*	*thing*
dear	*near*	*think*
for	*nor*	*use*, (verb) *whose* (³)
from	*see*, *use* (³) (noun)	*very*
Lord	*so*, *us*	*which*

KEY TO EXERCISES IN LAST LESSON.

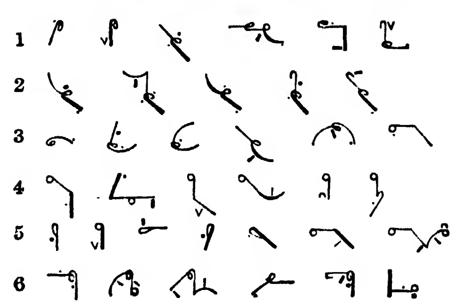
1 Play, bray, addle, adder, ogre, grow, glow, try, cry, brew.
2 Bible, breath, breakers, library, teacher, tipple, fiddle, sugar, problem.



1 Flaw, flag, fledge, flame, flung, rifle, revel, inflammable.
2 Channel, tunnel, final, partial, roguishly, Ethelred, venal, eternal.
3 Other, through, cover, frame, thrush, fresh, afresh, gather, thrice.
4 Fraud, coffer, lever, leisure, tanner, banner, Homer, thinker.
5 Differ, Fred, rubber, rubble, shiver, shovel, France, Fleming.
6 Frugal, keeper, initial, Michael, fever, trifle, brutal, joyful.



1 Supple, subtle, sable, splice, suckle, splash, saddle, saddler, sublime.
2 Display, possible, classical, exclaim, disclaim, disable, cycle, bicycle.
3 Signer, designer, soother, dishonour, suffer, blissful, sooner, savoury, deceiver.
4 Sprig, super, supreme, spruce, spring, sprawl, straw, cedar.
5 Stitcher, switcher, stagger, swagger, stutter, sweater, sucker, sabre, stopper, sober.
6 Descry, disclose, describe, disclosure, mistress, expressly, expositor, outsider, outstrip.



Continued

WHAT WE KNOW OF THE ATOM

Mixtures and Compounds. Atoms and Molecules. Atomic and Molecular Weight. Fixed and Multiple Proportions. Chemical Equivalents

By Dr. C. W. SALEEBY

The Atomic Theory. In order to understand the real meaning of the table on p. 517, we must consider at length the *atomic theory*, which we have described as the logical basis of modern chemistry. The atomic theory regards matter as being built up of minute particles, which are called atoms, a name which literally means "uncut" or indivisible; and it assumes that the difference between one element and another — the difference, say, between gold and oxygen—is due to a difference in the nature of the atoms in each case. Further, we assume that every atom of gold is exactly the same as all other atoms of gold, every atom of carbon exactly the same as all other atoms of carbon, and that this holds true whether the carbon be situated in the sun or in the human body, or in a comet or anywhere else. An *element* or elementary substance is one which consists of an indefinite number of atoms of the same kind. A *compound* consists of atoms of at least two kinds.

Are we to say, then, that a compound is simply a mixture? This is very far from being the case. Let us take familiar instances, air and water. The air is a mixture of gases—that is to say, a mixture of gaseous elements. These elements retain their own characteristic properties. The atoms of any one of these elements may go about in each other's company, but not in the company of the atoms of any other element of the mixture. Now the essential character of a compound is that the atoms of one element go about in the company of the atoms of one or more *other* elements. Amongst the elements in the air, for instance, are oxygen and nitrogen. These are mixed, but not combined. But the substance we call water also consists of two gases—oxygen and hydrogen, yet it displays none of the properties that we attribute to either of those elements, nor does it display a sort of average or blend between them. It is totally different.

Compounds Distinguished from Mixtures. Indeed, this case furnishes us with a particularly good instance of the difference between a compound and a mixture. It is quite an easy thing to measure out a certain quantity of hydrogen and a certain quantity of oxygen, and to mix them together in a tube. The result is simply a mixture of two transparent gases. It is not in the least like water, has none of the properties of water, and, in short, is not water; yet water consists of these two elements in exactly the same proportions as those in which they are present in the tube in question. This can be readily proved by simply passing an electric spark through the tube. The result is that the gases disappear, and there is found in their place a drop or two of water. This drop of water consists of the very gases that were present in the mixture, and can, if necessary, be decomposed, with the reproduction of the mixture as before. What, then, constitutes the essential difference—a difference which, in point of fact, is very great—between a mixture of oxygen and hydrogen on the one hand and a compound of oxygen and hydrogen on the other hand?

Molecules. In order to answer this question, we must consider a new conception which is represented by the word *molecule*—literally, a little mass. This word used often to be employed when atoms were meant. It was, for instance, the word used by Clerk-Maxwell in his famous address delivered to the British Association and referred to in the section on Physics. [See PHYSICS.] But Maxwell was referring to what we now call atoms. We must sharply distinguish between the modern uses of these two terms.

Let us take, for instance, the gas hydrogen, which we believe to be composed of a number of atoms, all exactly similar. We find reason to believe that these atoms do not go about singly, but that they pair with one another, and each pair of hydrogen atoms constitutes a little system of its own, which we now call a molecule. In the case of the mixture of hydrogen and oxygen, we should find, if our eyes were keen enough, simply a collection of molecules, consisting either of two hydrogen atoms linked together or of two oxygen atoms linked together. But if we made a similar inspection of the water which is formed when a spark is passed through this mixture, we should find the essential difference between a mixture and a compound. The mixture was simply a mixture of molecules of hydrogen and molecules of oxygen—each molecule, as we have said, consisting of two similar atoms; but in the compound, just because it is a compound and not a mixture, there is no such mixture of molecules.

The Molecule of Water. All the molecules of a compound are of the same kind, just as all the molecules of an element are of the same kind; but whereas the molecules of an element are composed of similar atoms, the molecules of a compound are formed of dissimilar atoms. Whereas the mixture of hydrogen and oxygen consisted of a number of molecules containing two atoms of hydrogen and a number of molecules containing two atoms of oxygen, the compound called water

formed from that mixture contains only one kind of molecule, compounded of atoms of oxygen and atoms of hydrogen, whilst no molecules consisting only of hydrogen atoms or only of oxygen atoms would be found in it.

Now these facts may be very simply expressed by the judicious use of the symbols which we have noted in our table of the elements. We may say that the mixture consisted of a number of H_2 molecules and a number of O_2 molecules —the two standing for the number of atoms in each molecule ; but in the compound there are no H_2 or O_2 molecules. The molecules are all of one kind, and each consists of two atoms of hydrogen and one atom of oxygen. We express this construction of the molecule of water by the formula H_2O. That is the formula of water ; and it expresses the fact that each molecule of water consists of two atoms of hydrogen and one atom of oxygen. Perhaps the formula would be more intelligible if it was written H_2O_1, but the $_1$ is never printed. It is understood that when the symbol of an element occurs without any figure after it, *one* atom of that element is indicated.

An Unstable Compound. The reader will very probably ask why it is that one atom of oxygen should combine with two of hydrogen. Why not one with one or two with two ? That question raises many important considerations, which will later be discussed ; but we may here point out in passing that the combination of two atoms of oxygen with two atoms of hydrogen is known and yields a compound called Peroxide of Hydrogen. This is a very unstable compound, since it contains, so to speak, one atom of oxygen in each molecule more than is comfortable, and hence it is very apt to lose this superfluous oxygen, which, when it goes, leaves H_2O, or water, behind. This property of giving off oxygen endows peroxide of hydrogen with useful properties.

Amongst other purposes, it is often applied to the hair for the purpose of lightening its colour. It produces a characteristic yellow colour—" peroxide hair "—which is due to the fact that the oxygen given off from the H_2O_2 enters into combination with the dark pigment of the hair and produces a pigment of a lighter colour now fashionable.

Atoms in Pairs. Let us return now to the consideration of the molecules of an element —molecules consisting of similar atoms, as distinguished from the molecules of a compound, which consist of dissimilar atoms. There are some elements the atoms of which go about singly. Mercury and zinc are examples. In the great majority of elements the atoms go about in pairs. We have seen that this is so in the case of oxygen and hydrogen But the precise number of atoms in the molecules of elements varies with circumstances. Let us consider, for instance, the peroxide of hydrogen, H_2O_2, of which we have spoken. We have said that it owes its use in bleaching an actress's hair to the fact that it gives off oxygen, which combines with and alters the hair pigment ; but the reader will object that the hair is always in contact with the oxygen of the air. Why does not that bleach the pigment ? A very satisfactory answer to this question can be obtained.

Let us consider the case of the atoms of oxygen in the air. Each of them is in combination with one of its fellows, thus forming a molecule of oxygen, and is, so to speak, satisfied. It has no desire to seek other partnerships (of course the reader will understand that we are using symbolical ways of talking ; these desires and satisfactions are now being explained in terms of electrical forces). The atoms of oxygen forming the molecules that surround the hair do not attack the hair pigment, because they are satisfied with each other.

The Birth of an Element. But let us imagine that we can watch what happens to a molecule of peroxide of hydrogen, H_2O_2. As we have seen, this molecule contains one atom of oxygen too many for comfort, or, to use a less symbolical term, too many for *stability ;* and the odd atom of oxygen constantly tends to escape from the molecule, leaving behind a molecule of water—a molecule so stable that men studied chemistry for centuries before they discovered that it could be broken up—that water is not an element Now, it is one atom of oxygen that leaves the molecule of H_2O_2, but it is the peculiarity of an atom of oxygen, like nearly all atoms, that it must have a partner. As a rule, we may imagine the atoms of oxygen that leave two adjacent molecules of peroxide of hydrogen to unite with each other, and thus form a molecule of oxygen O_2 ; but if, just at the moment of their escape, there are any other substances present with whose atoms the atoms of oxygen can combine, instead of merely combining with each other, they are apt to do so, and this is why the peroxide of hydrogen can bleach the hair by giving oxygen to it, whilst the oxygen of the air is quite unable to do so.

When the atoms of any element are caught, so to speak, in the act of combining with each other—that is to say, in the act of seeking companions—the element is said to be in the *nascent* state, which literally means the state of being born. It is at these moments that the chemical properties of the element are most strikingly manifest. In the language of chemistry, then, we say that peroxide of hydrogen, H_2O_2, bleaches the hair in virtue of the fact that it liberates *nascent oxygen ;* and the reader now understands why nascent oxygen should be more chemically active than oxygen that is not nascent—that is to say, than oxygen the atoms of which have already settled down to a humdrum existence in stable pairs.

The Properties of Ozone. We have seen, then, that the atoms of oxygen may sometimes be caught *single*. The formula for oxygen at such a moment would be O (the $_1$ being understood) ; and we have seen that, as a rule, the atoms go about in *pairs*, indicated by the formula O_2 ; but we further discover that, under certain conditions, the atoms go

about in *trios*, in which case the formula of the oxygen must be O_3, indicating that each molecule consists of three atoms. A special name has been given to this modification of oxygen, which is called *ozone.*

Now, just as peroxide of hydrogen, H_2O_2, is an unstable substance, always eager to get rid of its superfluous oxygen and relapse into the more familiar substance water, so, similarly, ozone, O_3, is an unstable substance, always anxious to get rid of its superfluous atom of oxygen, and settle down into the commoner kind of oxygen O_2. Whenever there is any opportunity for getting rid of the superfluous atom of oxygen to anything that will have it, the ozone seizes the chance. Indeed, two molecules of ozone left by themselves will very soon turn into three molecules of ordinary oxygen.

A Chemical Equation. Such a change may be expressed in the first chemical equation to which we shall introduce the reader:

$$2O_3 = 3O_2$$

This simply expresses the idea that two atoms liberated from two adjacent molecules of ozone have united with each other to form a third atom of oxygen, which is added to the two atoms of oxygen which were left by their departure. The equation is a true equation, as the reader will see when he applies the test of ascertaining whether all the atoms named on the one side of the equation, and no more, are accounted for on the other side of the equation. It is a true equation, because it represents six atoms on each side. Of course, the reader will understand that we have been talking in very metaphorical language, since no one can possibly see, or experiment with, two molecules of ozone or any other substance; but there is no doubt that our metaphor corresponds with the actual fact.

Now, we do not know of any form of oxygen in which the molecules consist of more than three atoms; but there are certain substances which possess four atoms to the molecule. Of these, phosphorus and arsenic are examples. Thus the formula for phosphorus must not be written P or P_2, but P_4. When we come to examine the behaviour of atoms of sulphur, we find that, at certain temperatures, they go about in pairs, and the formula for sulphur at such temperatures must be S_2; but at other temperatures they seem to go about in sixes, and the formula for sulphur at these temperatures must be S_6. We can now readily understand the relation of what is called *molecular weight* to *atomic weight.*

Molecular and Atomic Weight. The *molecular weight* of any body containing, say, four atoms to the molecule will plainly be four times the atomic weight; but, surely, before discussing molecular weight, we must understand what we really mean by atomic weight.

Perhaps the most fundamental character of matter is its mass. [See PHYSICS.] We have seen, of course, that we have no absolute measurement for mass, but can merely estimate the mass of one substance as compared with that of another. We have already seen that the mass of the hydrogen atom, being the lightest known, used to be taken as the standard of measurement, but that now there is a tendency to prefer oxygen as the standard, and to represent the weight of the oxygen atom as 16. Plainly, in such case, the molecular weight of oxygen must be 32; the molecular weight of ozone must be 48; the molecular weight of hydrogen must be 2; and the molecular weight of water, H_2O, must be $18 = 1 + 1 + 16$.

The Law of Fixed Proportions. What, then, are the chemical facts that may be explained on this atomic theory, which asserts that matter consists of atoms of different kinds, the atoms of each element being of a constant and definite weight—weight being the means by which we express the amount of matter in, or the mass of, the atom which we weigh? The first law which may be explained on the atomic theory, and on no other which has been suggested, is the law of *fixity of proportions*, or *fixed proportions.*

This law asserts that every chemical compound —assuming, of course, that it is pure—always possesses the same constitution—that is to say, is always composed of the same fixed proportions of the elements that go to compose it. Let us take, for instance, the case of the simple compound called water. From whatever source we obtain a specimen of water, and under whatever conditions we examine it, it is invariably found that, when the water is decomposed, eight-ninths of its weight is composed of oxygen and one-ninth of hydrogen. What is true of water is true of every other compound. If the compound is what it professes to be, it is invariably found to contain absolutely fixed proportions by weight of the different elements that go to compose it.

An Experimental Fact. Observe here the difference between a mixture and a compound. Oxygen and hydrogen may be mixed in any proportion; but in the combination of them called water the proportion is absolutely constant — one-ninth hydrogen, eight-ninths oxygen.

Now, this experimental fact as to the fixed proportions (by weight) of the elements in water tallies precisely with the facts we have observed as to the relative weight of oxygen and hydrogen, for we found that oxygen is approximately sixteen times as heavy as hydrogen; and, on the atomic theory, we asserted that water consists of a number of molecules, each of which contains two atoms of hydrogen and one of oxygen. If that theory were true, every molecule of water would consist of hydrogen to the extent of one-ninth part of its weight, whilst oxygen would supply the other eight-ninths, since the one atom of oxygen weighs sixteen and the two atoms of hydrogen taken together weigh two. If, then, water is made up of a number of such molecules, any quantity of water that we examine at any time should similarly prove to consist of one-ninth of

hydrogen and eight-ninths of oxygen; and that is what is found.

The Law of Multiple Proportions. The second law which can be explained by the atomic theory, and by no other that has been suggested, is the law of *multiple proportions.* This may be simply illustrated by taking two familiar substances, such as nitrogen and oxygen. There are five known compounds of nitrogen and oxygen. When we come to weigh the proportions of nitrogen and oxygen in these five compounds, we find that they may be arranged in a series of a very significant character. If we represent the weight of nitrogen on the top line and the weight of oxygen on the bottom line, we find that the ratios in the five compounds are as follows:

$$\frac{14}{8} \quad \frac{14}{16} \quad \frac{14}{24} \quad \frac{14}{32} \quad \frac{14}{40}$$

Now, 14 is the atomic weight of nitrogen, and 16 is the atomic weight of oxygen. Thus, on the atomic theory, we can very readily explain the fact that there are five compounds of oxygen and nitrogen in which the weights of the two constituents are arranged in multiple proportion, 8, 16, 24, and so on. We can explain the first compound, in which we found the ratio of nitrogen to oxygen as 14 to 8, on the atomic theory, by asserting that this compound consists of the union of two atoms of nitrogen to one of oxygen. This is obvious, if for 14 to 8 we read 28 to 16, a ratio which suggests the composition we have stated. The formula of this substance is N_2O. It is known as laughing-gas, and whenever we analyse laughing-gas we find that it consists of nitrogen and oxygen in the proportions by weight of 28 and 16. The next compound of oxygen and nitrogen, in which the weights of the two elements are in the ratio of 14 to 16, must plainly consist of molecules which have one atom each of oxygen and nitrogen. Its formula is $N\,O$. Similarly, the next compound and the two next show a simple increase in the ratio of oxygen to nitrogen.

Five Kinds of Molecules. We have to conclude that two atoms of nitrogen unite respectively with one, two, three, four and five atoms of oxygen, and form these five different kinds of molecules, whose compositions illustrate the law of multiple proportions, and can be explained only by the atomic theory. The five formulæ are as follows: N_2O, N_2O_2, N_2O_3, N_2O_4, N_2O_5—and these formulæ illustrate the relations of the substances; but it is more accurate to write $N\,O$ and $N\,O_2$ instead of N_2O_2 and N_2O_4, since it is probable that the simpler formulæ represent the actual way in which the atoms go about; though the double formulæ, when inserted in their place in the series, make more obvious the nature of the relation between the five compounds. If the reader will turn back to the ratios $\frac{14}{8}$, etc., which we gave in starting, he will see how perfectly they are explained on the atomic theory. If that theory is rejected, these ratios, and numberless others that might be cited in illustration of the law of multiple proportions, must be denied their only and obvious meaning.

The Law of Chemical Equivalents. The third law which can be explained by the atomic theory is known as the law of *chemical equivalents.* This, also, can be easily illustrated. Let us take a given quantity of hydrogen, say a gramme [for the meaning of this term, see PHYSICS]. Now, a gramme of hydrogen will unite exactly with eight grammes of oxygen, forming nine grammes of water and leaving over no oxygen and no hydrogen. Similarly, we find that if we take one gramme of hydrogen and 35·4 grammes of chlorine [refer to the table already printed, and note that this proportion is exactly the proportion of the atomic weights of hydrogen and chlorine], we find that the two will unite exactly, giving us 36·4 grammes of a compound called hydrochloric or muriatic acid, the formula of which is $H\,Cl$.

Now, the law of chemical equivalents states that chemical quantities which have equal power of forming chemical compounds are equal to one another. Thus, according to this law, eight grammes of oxygen are chemically equivalent to 35·4 grammes of chlorine, since each of these two quantities unites exactly with one gramme of hydrogen. But when we say that eight grammes of oxygen are chemically equivalent to 35·4 grammes of chlorine, we are saying in other words, on the atomic theory, that (if we double the two quantities, the relation is seen at once) two atoms of chlorine are chemically equivalent to one atom of oxygen, since two atoms of chlorine will weigh 70·8 and one atom of oxygen weighs 16. The ratio 70·8 to 16 is the same as the ratio of 35·4 to 8. Now, it is found that two atoms of chlorine are indeed equivalent to one atom of oxygen, for two atoms of chlorine will unite with two atoms of hydrogen (forming two molecules of $H\,Cl$), and one atom of oxygen will also unite with two atoms of hydrogen (forming one molecule of water, H_2O).

We may take the atomic weights of any elements at random and use them as our guides in indicating the proportions of the elements that may be expected exactly to combine with each other in the formation of compounds; and we find that the table of atomic weights is always a guide in such cases. Further confirmation of the atomic theory will be found in the subsequent chapter on the laws of chemistry.

Molecular Weight. Let us now return to the consideration of molecular weights—that is to say, the weights of molecules—which must necessarily depend upon the weights of the different atoms which compose them. The subject of molecular weights is exceedingly important, for we have already seen that elementary substances composed of only one kind of atom may appear in very different forms, having very different

properties, according to the number of the atoms that go to form each molecule. We saw this in the case of oxygen, O_2, and ozone, O_3. The importance of the subject of molecular weights is not fully realised in many text-books.

Many writers, for instance, are contented to use H and O as symbols for hydrogen and oxygen; but this will not do. H and O are simply short ways of writing the names of Hydrogen and Oxygen. The symbol for the substance we call oxygen is not O, but O_2. If we do not recognise this distinction, we are left with only one symbol, O, to describe the two very different substances, oxygen and ozone. Similarly, in the writing of equations, we must never shirk the extra trouble involved in using our formulæ properly. For instance, the easiest way of writing an equation to represent the decomposition of peroxide of hydrogen, H_2O_2, would be

$$H_2O_2 = H_2O + O.$$

But this is a very unsatisfactory way of writing the equation, unless we use it to express the fact already noted that for a moment the oxygen atoms are in a state of dissociation from each other, so that the oxygen is nascent, as chemists say. The actual result of decomposition of peroxide of hydrogen is the production of water and of ordinary oxygen—oxygen in which the oxygen atoms go about in pairs, and the formula of which is therefore O_2. Now, in order to express this properly, we must go to the trouble of doubling all the terms of the equation, and we must write it thus:

$$2\ H_2O_2 = 2\ H_2O + O_2$$

Similarly, the reader will find an illustration of the proper way of writing chemical equations if he turns back to the equation—the first we employed—that illustrates the decomposition of ozone into oxygen. It would not do at all to have written $O_3 = 3\ O$, because O stands for nothing. It is simply a short way of writing the name Oxygen; but the element oxygen is composed of two atomed molecules, and, therefore, we have to write our equation as we did write it in order to show that the product of the decomposition consists of a certain number of two-atomed molecules, which we represent by the formulæ O_2. Having corrected this common error, and having undertaken never to sanction it, we may now pass to the consideration of molecular weights.

Actual Size of Molecules. The molecular weights to which we have hitherto referred are, of course, purely relative, like the atomic weights; but we may first ask ourselves whether anything is known as to the absolute size and weight of molecules. This subject belongs rather, perhaps, to the domain of physics than to the domain of chemistry; but, nevertheless, the chemical student must be interested to learn whether anything is known as to the actual size of these molecules to which he has to devote so much attention. A great deal of labour has been expended on this subject. Hitherto we have referred only to molecules containing a very few atoms, but there is an immense number of kinds of molecules that are relatively large and heavy, and contain hundreds of atoms. It is believed that the largest and most complex molecule known is that of hæmoglobin, which is the red colouring matter of the blood. This molecule is supposed to contain more than a thousand atoms belonging to the elements carbon, oxygen, hydrogen, nitrogen, iron, and possibly phosphorus.

The actual or absolute size of this enormous molecule has not been studied; but Lord Kelvin's calculations lead us to conclude that if a drop of water were magnified to the size of the earth, its molecules would be of a size ranging somewhere between that of small shot and that of cricket balls.

So much for the absolute size and weight of molecules. We must now consider a subject of much more importance to the chemist—which is their relative weight, and which he always means when he speaks of molecular weight.

Weight of a Volume of Gas. Avogadro's law, afterwards to be discussed, states that equal volumes of all gases at the same temperature and pressure contain the same number of molecules. This may be otherwise expressed by saying that the molecules of all gases occupy precisely the same space, given that they are placed under the same temperature and pressure. From our discovery of this law we are enabled to devise a method of ascertaining the molecular weight of a substance. We take the substance in the form of a gas or vapour (if the substance is not naturally a gas, we vaporise it or make into a gas for our purpose).

Assuming the truth of Avogadro's law, we see that a given volume of any gas, under given conditions of temperature and pressure, must differ from a similar volume of hydrogen under similar conditions precisely in so far as its molecules are heavier than those of hydrogen, for the law states that we are dealing with the same number of molecules in each case. If, then, the volume of the gas possesses a weight twice as heavy as the weight of a similar volume of hydrogen, the necessary inference is that each molecule of this gas weighs twice as much as a molecule of hydrogen.

Thus we can ascertain the molecular weight of any substance that can be studied in the form of a vapour or gas; but, unfortunately, a great many substances cannot be vaporised, and in their case other methods must be employed. These will not be dealt with at length here. The most important of them depends on the fact that, when a given quantity of any substance is dissolved in a liquid which simply dissolves it and does not affect it chemically, it lowers the freezing point of the liquid in exact proportion to its own molecular weight, which can thus be determined. A similar principle can be applied in various other ways, and by means of these freezing-point and boiling-point methods a great deal of information has recently been acquired concerning the molecular weights of a large number of elements, especially the metals and their nearest allies.

Continued

GUARDIANS OF PUBLIC HEALTH

Medical Officers of Health. Sanitary Inspectors. Inspectors of Nuisances. Other Health Appointments. Posts for Women. Salaries and Duties

Continued from page 575

By ERNEST A. CARR

NO finer work is done under the direction of a local authority than that performed by its public health department. From quelling an outbreak of infection to closing foul bakehouses or abating the evils of overcrowding, the public health officials are perpetually doing battle in a thousand ways with dirt and disease, the indifference of employers on sanitary matters, and the ignorance of the employed.

The Medical Officer of Health. The command of this civil force is in the hands of the Medical Officer of Health for the borough or district. His is a very responsible post, especially in densely populated or poverty-stricken areas. As the sworn foe alike of the jerry-builder, the rapacious "house-farmer," and the exploiter of insanitary slums and "rookeries," he has to combat a vast amount of interest, apathy and guile, as well as that "sheer ignorance" to which Dr. Johnson unblushingly laid claim. This task requires not merely a highly qualified sanitary expert, but a sound administrator—impartial, shrewd, and resolute.

The position of Medical Officer of Health offers many attractions to able young medical men who have specialised in sanitary science and have had some experience as general practitioners, but are unable to purchase a lucrative practice, and unwilling to spend their best years in establishing one. Difficult as the duties are, they afford a means of serving the public welfare directly and with real effect. By comparison, at least, with the dull round of a practice in a sleepy parish, they are full of interest and variety, and they are free from the harassing conditions of fluctuating income and irregular hours which are the bane of a general practitioner's life. The salaries with which they are remunerated naturally cannot compare with those of the great consultants; but, in comparison with the low average earnings of fully qualified medical men, leading appointments in the municipal service are liberally repaid.

Qualifications. The appointment of a Medical Officer of Health rests with the Borough or District Council concerned, but is subject to the sanction of the Local Government Board, which retains practical control by authorising the payment from national funds (in most cases) of half the salaries of approved officers, and by specifying the qualifications necessary for its approval. These may be found set out in formal language in Section 18 of the Local Government Act, 1888. Briefly, the only essential for Medical Officers of Health for the smaller districts is that they shall be legally qualified to practise surgery, medicine, and midwifery. With regard to more important areas, the Board's requirements are naturally more stringent

The Value of the D.P.H. The section stipulates that (*with certain exceptions in favour* of established Medical Officers) no person shall be appointed Medical Officer of Health of a county, or of any district having a population of 50,000 or more, unless, in addition to the qualifications given above, he is registered as the holder of a diploma in Sanitary Science, Public Health, or State Medicine.

Of these three alternatives the most general is the Public Health Diploma, entitling its possessor to affix D.P.H. to his other qualifications. Almost all the universities award it on examination [see page 710], as well as the Conjoint Board of the Royal Colleges of Physicians and Surgeons. In addition, Dublin University gives a diploma in State Medicine; while that in Sanitary Science is granted by Durham, Victoria, and the Royal University of Ireland. The requisite qualification is also secured by graduating in the following special subjects: M.D. (London) in State Medicine; B.Sc. or D.Sc. (Edinburgh) in Public Health; or like degrees in Hygiene at Durham University.

For those medical men who wish to qualify specially for the D.P.H. with a view to municipal work, a valuable course of instruction is provided by the Royal Institute of Public Health. This comprises lectures and laboratory work in hygiene and public health, and in bacteriology. The course also includes under the former head practical sanitary training, fever hospital administration, and three months' instruction in sanitary law, sanitary engineering, vital statistics, and other branches of public health work, reinforced by practical demonstrations and visits to municipal and other sanitary works. A detailed syllabus of this course will be found in the official calendar, which may be obtained from the secretary of the Royal Institute of Public Health, Russell Square, London, W.C.

The Medical Officer's Work. The student who intends to win eventually a chief appointment in one of the leading towns will not rest content with the minimum requirements prescribed by statute. He will be wise to secure every degree and diploma within his grasp. In no other department of the municipal service, probably, are professional and scientific attainments so valuable in procuring advancement; and it is generally admitted that leading public health officers rank, as a class, with the most highly qualified members of the medical profession.

An Order of the Local Government Board defines the general duties of a Medical Officer of Health. Apart from advisory duties and the keeping of certain books and statistics, they may be conveniently summarised.

He shall inform himself as far as practicable respecting all influences threatening to affect injuriously the public health within the district.

He shall inquire into the origin and distribution of diseases within the district, and ascertain to what extent the same have depended on conditions capable of removal.

He shall by periodic and other inspection of the district keep himself informed of the conditions injurious to health existing therein.

On receiving information of the outbreak of any dangerous infectious or epidemic disease, he shall visit without delay the spot where the outbreak has occurred, and inquire into the causes and circumstances of such outbreak, and take due measures to prevent its extension.

He shall direct or superintend the work of the Inspector of Nuisances, and on receiving information from the latter that his intervention is required in consequence of any nuisance injurious to health, or of any overcrowding in a house, he shall, as early as practicable, take the proper legal steps thereon.

When requisite, he shall himself inspect and examine any animal, carcase, meat, fish, etc., exposed or deposited for the purpose of sale, and intended for the food of man, which is deemed to be unfit for the food of man; and thereupon shall give such directions as may be necessary.

The Work under a Small Authority. It is customary for local authorities to specify these duties more precisely and to enlarge upon them. The supplementary list that follows was recently framed by the council of a borough just large enough to make the D.P.H. diploma essential. The duties set out are typical of the class of smaller appointments that a public health diplomate might accept for his first responsible position.

He shall be the Chief of the Health Department, and have control of the Sanitary Staff.

He shall act as Medical Superintendent of the Borough Hospitals.

He shall be responsible for the scavenging and street cleansing of a specified portion of the Borough.

He shall act as Medical Supervisor under the Midwives Act, 1902.

He shall attend all Meetings of the Health Committee, and of any other Committee when required.

He shall keep himself fully acquainted with such matters as Water Supply, Drainage (with the exception of Public Sewers), Scavenging, Insanitary Dwellings, and Overcrowding in the Borough.

He shall assist and advise the Council and the Health or other Committee on any Bill in Parliament with reference to the Public Health, the Water Supply, etc., and shall give evidence in legal or other proceedings when required.

He shall give assistance and advice when required in connection with the Sale of Food and Drugs Acts; and shall perform any other duties imposed by the Council.

In larger boroughs, hospital duties are entrusted to a special officer, and the control of the street-cleansing staff to another; while the public health expert is occupied instead with the more complex and far-reaching questions of sanitation that are constantly arising in congested districts. It should be realised that in any event the medical officer's duties are advisory, controlling, and professional rather than executive—a fact which the somewhat grimly phrased list given above is calculated to obscure.

He is the council's sanitary and scientific expert, consulted by the Health Committee and by his staff on all difficult and doubtful questions within his province. He is specially called upon, as a skilled authority, to examine all food seized by his officers as unsound, and to inspect drainage works, insanitary premises, etc., in respect of which serious issues are likely to arise. Otherwise he is responsible as expert in charge of a department rather than as executive officer.

Salaries. Medical Officers of Health, like many other municipal servants, are remunerated on a scale varying with the importance of the authority employing them. The finest appointments are in busy towns, and the next best under the County and the London Borough Councils. A good idea of their general range of value may be gathered from a list of stipends actually paid:

London County Council, £1,250.
City Corporation, £1,000.
London Borough Councils, £800—£1,200.
Port of London, £650.
Manchester, £950.
Hampstead, £600.
Chester, £500.
Scarborough, £400.
Acton Urban District, £500.
Merthyr Tydfil District, £400, rising to £500.
East Ham, £400, by £25 annually to £500.
Tynemouth, £300, by £25 annually to £400.
Devonport, £300, rising to £450.

Holders of the major appointments are debarred from private practice. Many of the smaller district councils, however, have no need of a medical officer's full time services, and appoint general practitioners for partial and occasional service at small stipends ranging between £60 and £250 a year.

The Best Practical Training. The highly specialised and practical studies needed to secure the D.P.H., and the scientific nature of his duties, make previous municipal training less essential for the medical officer than for most other servants of the public. Of the towns in our list, both Devonport and Merthyr were secured by private practitioners. Yet it rarely occurs that a post of the first rank is won by men who have had no previous experience of the sort. Thus, the City Corporation's medical officer previously held the same office for the Port of London. His successor at the port was formerly Medical Boarding Officer at Gravesend, and afterwards had charge of Denton Hospital. The doctor now in medical charge of Chester held assistant rank at Stepney, and Acton's medical officer was previously chief in a smaller district.

The best practical training for a valuable post under a corporation is probably secured by a few years' service either as principal medical officer in a small district or assistant or deputy in a larger one. The county councils, however, who have to administer the Education Acts, are often favourably impressed by experience in children's or general hospitals, and by special knowledge of diseases of the eyes, ears, throat, and chest.

Deputy medical officers receive from £300 to £500 a year, and assistants between £250 and £450, the former being the more usual figure, as a beginning salary at least.

Other Medical Appointments. County hospitals and asylums, and those of the larger boroughs, afford a considerable number of fairly well-paid medical posts, both resident and visiting. The remuneration for resident appointments usually includes board, quarters, light and fuel, in addition to salaries ranging from £120 to £150 or more, for junior assistants, up to £500 or £650 for the medical superintendent in charge. Under the London County Council the scale of pay at Asylums is as follows: Medical Superintendents, £1,000, with an unfurnished house; senior assistants, £300, rising by £25 annually to £400 a year, with board and quarters of the estimated value of £85 a year; junior assistants, £180 to £220, with similar advantages. The L.C.C., it may be noted, forbids its junior medical assistants to marry, but extends that privilege to the seniors.

A principal resident appointment is seldom, if ever, given to a general practitioner, but is reserved for a specialist in mental or other diseases. Most medical superintendents have had several years' hospital experience, at least in a subordinate capacity.

Visiting appointments are usually offered to men who have reached some distinction in general or consultant practice. They are variously remunerated, the fees in some instances being merely nominal, in others as much as 200 or 300 guineas a year.

Every county or borough administering the Elementary Education Acts employs at least one chief medical officer under its Education Committee, at a salary of from £500 to £700, with several assistant or district officers receiving about half as much.

Police Surgeons. The leading police forces of the country are usually in medical charge of a salaried chief officer, and of district surgeons, repaid by fees. The Metropolitan Police surgeon's salary, for example, is £600, and a like post under the City Corporation is rewarded with £635 a year. Local practitioners of good standing are appointed divisional or district police surgeons, with fees for the actual duties performed. In London, where there is an allowance proportionate to the strength of the division, with special fees of 3s. 6d. per day visit to the station and 7s. 6d. per night call, they form a valuable addition to the earnings of a private practice, amounting in the busier districts to £400 a year or more.

Sanitary Inspectors. If the Medical Officer of Health is the professional head of his department, the Sanitary Inspector, or Inspector of Nuisances, is its trained right-hand. He is the general executive officer for the supervision of all works affecting the health of his district and the enforcement of sanitary measures against those who would imperil it. On his zeal and judgment—and especially on his integrity—very important issues depend. The inspection and testing of drainage and sanitary work of every kind, the abatement of nuisances due to dirt, neglect and overcrowding, the supervision of common lodging-houses, the seizure of diseased and adulterated food, are among the many activities of this valuable public servant.

Duties of so wide a range can only be performed by a skilled practical expert. Especially is this the case in a crowded district, where the problems of health and disease are at once more complex and more pressing. Hence it is that the Local Government Board intervenes to ensure the appointment of properly qualified persons as Inspectors of Nuisances, much as it does in respect of Medical Officers of Health, but with this important difference—that, except for London appointments, it prescribes no specific qualification.

London Sanitary Inspectors. These officials are the most highly trained members of their class. They are appointed only after furnishing satisfactory proof of training, and passing a special examination held by the Sanitary Inspectors' Examination Board, particulars of which are given in the accompanying table.

The evidence of training required is either three years' duty (prior to 1900) as inspector in a district of 5,000 or more inhabitants, or a certificate of instruction in the practical studies of an inspector, etc., from an institution recognised by the Board. According to the latest returns, the London inspectors number 281, excluding women. Their duties and the salaries they receive differ so slightly from those of provincial officers that on these points we may most conveniently discuss both classes of appointment together.

Provincial Inspectors of Nuisances. For posts outside the London area the Local Government Board imposes no standard of training, but practically leaves health authorities a free hand in their choice of candidates. Except in the smallest rural areas, however, the appointing council generally requires applicants to possess a certificate of competency issued by one of the recognised examining bodies.

The chief of these are the Sanitary Inspectors' Examination Board (already referred to), the Sanitary Institute, and the Universities of Victoria and Liverpool. The Royal Institute of Public Health examines candidates for Irish posts only. Probably the most generally accepted certificate is that of the Sanitary Institute, the examination for which is also given in the appended table. Prospective candidates may be interested to learn that the Sanitary Institute has made arrangements with a number of authorities by which suitable persons may accompany inspectors on their visits, inspections, etc., and thus gain the practical knowledge required of all applicants for the inspector's certificate. Particulars and specimen examination papers can be obtained from the secretary of the Sanitary Institute, Parkes Museum, Margaret Street, London, W. As every sanitary authority is required to appoint at least one inspector, the total number of these posts is very great.

A General Order of the Local Government Board defines the duties of sanitary inspectors

and inspectors of nuisances. It is too lengthy a document for inclusion here, but can be purchased for 6d. from Messrs. Knight & Co., Ltd., of 227, Tooley Street, S.E.

Duties and Salaries. The general character of the work is sufficiently indicated by the examination subjects given, and by what has already been said of the inspector and his professional chief, the Medical Officer of Health. It may be added that his hours of duty are irregular and often long, and his work as trying as it is useful. Candidates must usually be between 25 and 40 or 45 years of age. The London County Council, however, which employs a number of health inspectors, imposes on applicants the narrower limits of 30 to 40 years.

The average value of inspectors' posts is shown by the following salary lists:

LONDON. Chief Inspectors, £250 to £350.
L.C.C. Inspectors, £150 to £250.
Westminster, £150 by £10 to £220.
Finsbury, £130 by £10 to £180.
Southwark, £120, by £10 to £180.
Battersea Food Inspector, £180; general, £120 to begin.
Wandsworth, £188.

PROVINCES. Manchester, superintendent, £500; chief inspector, £250; smoke inspector, £200.
Newcastle, £200.
Longton, £150 to about £200.
Doncaster Rural District, £180.
Sheerness Urban District, £100, by £10 to £120.

Many men with a practical knowledge of building and sanitary work obtain assistantships, with salaries varying between £90 and £160 a year, and thus complete the all-round training requisite for an inspector's post.

Other Health Appointments. Towns with a large trade in cattle usually employ an expert staff of market and meat inspectors to supervise lairs and slaughter-houses, and to examine animals, both before and after death, for indications of disease. For the most part these officers are certificated inspectors of nuisances, holding also the special certificate in meat and cattle inspection awarded by the Sanitary Institute and kindred societies. Their average rate of pay is as follows: Inspector, from £160 to £200 or £220; chief inspector, £300; superintendent, £350 to £500. The posts available are relatively few, and are reserved for men of special training. The scope and conditions of the examinations are indicated in the table on the next page.

Among posts under the Health Committee accessible to the uncertificated may be noticed the cleansing inspector, at £110 to £160 a year, the street-keeper at a slightly lower average salary, and the manager of the dust destructor, who usually receives from £120 to £150, with a house, light and fuel in addition. Finally, we may note the positions available for women.

Work for Women. Until a few years ago there was no scope for feminine effort in the public health department, and although women are now employed there in yearly increasing numbers, there are still but three classes of appointment open to them—sanitary inspector, health visitor, or inspector of midwives.

Women sanitary inspectors are as yet but a small band, London employing 28 of them, and the provinces about 60 in all. But they have already done invaluable work in improving the sanitary condition of workrooms and factories where women and girls are employed, and there can be no doubt that this new avenue of women's activities will continue to enlarge. The qualifications required in lady inspectors are precisely the same as for men, which have already been discussed. The usual limits of age for candidates are 21 and 35, with an occasional extension to 40. These posts are well paid, as these typical appointments will show:

Westminster, £110, by £10 to £160.
Islington, £100, by £10 to £150.
Wandsworth, £120.

It is not surprising, therefore, that a number of women are training for inspectorships; but the competition hitherto has not been nearly so severe as for most other posts offered to women.

Health Visitors. Women health visitors have lately been appointed in many districts, at the instance of public medical men, with a view to checking the terrible ravages of infantile mortality among the children of the poor. On the value of such a service to the nation there is no need to dwell. The medical officer for Durham County, a persistent advocate of the new system, states that "to get in touch with mothers of to-day, and bring to their notice in a practical manner the proper methods of feeding and managing their children, I know of no better means than the appointment of women health visitors. In many of the large towns and some of the counties such women inspectors have been appointed, with excellent results in every case in which I have made inquiry."

The nature of a health visitor's work is best indicated by an extract from a recent municipal advertisement: "The duties will consist of house-to-house visitation, advising mothers as to the care and feeding of infants, visiting premises where females are employed, making inquiries into infectious cases, accompanying patients to isolation hospitals, and such other duties as the medical officer and inspector of nuisances may require." For these duties some practical training is essential, such as that of a maternity and general nurse. The salary varies from £90 to £120 a year.

Inspectors of midwives are busy county officials whose duties are sufficiently indicated by their title. The qualification usually insisted upon is that of a trained nurse; but as the salary paid is good—at least £120 a year and expenses—a number of these appointments have been accepted by qualified medical women. The lady doctor holding this office under the Manchester Corporation receives £250 a year.

NOTE. On page 320 it is stated that the Common Councilmen of the City Corporation are appointed annually by the votes of the Livery. It should read, instead, "by the votes of householders, or others holding the necessary occupation qualification, who are on the list of municipal voters."

Continued

EXAMINATIONS FOR HEALTH & SANITARY OFFICERS

1. EXAMINATION FOR THE PUBLIC HEALTH DIPLOMA

Numerous Bodies grant Degrees. The Schedule given below is typical. See text.

Examining Body, Time, and Place of Examinations.	Subjects of Examination.	Fees and Age Limit.
ROYAL COLLEGE OF PHYSICIANS, of London, and ROYAL COLLEGE OF SURGEONS, of England. January and July. London.	Candidates must possess qualifications in Medicine, Surgery, and Midwifery. Part 1 must be passed before Part 2 is attempted. Both parts are written, oral and practical. PART 1.—Chemistry, Physics, and Geology. Examination of Water and Air, including Analytical Methods. Chemical Composition of Foods, and Adulteration. Warming, Ventilation, Water Supply, and Drainage. Principles of Building Construction. Meteorology. Sanitary Engineering, including Sewage and Refuse. Microscopical Examination of Foods and Detection of Adulteration. Bacteriological Analysis. Disinfectants and Infectious Diseases. PART 2.—Laws relating to Public Health. General Epidemiology. Unwholesome Trades. Prevention of Nuisances. Parasitic Diseases. Climate. Effects of Overcrowding, Vitiated Air, Impure Water, Polluted Soil, and Bad or Insufficient Food. Duties of Sanitary Authorities. Vital Statistics. Population, Birth Rate, Marriage Rate, and Death Rate. Mortality. Sickness Rates. Occupation and Mortality. Life Tables.	£6 6 0 23 years and upwards. £6 6 0

2. EXAMINATION FOR SANITARY INSPECTORS IN LONDON

SANITARY INSPECTORS' EXAMINATION BOARD, 1, Adelaide Buildings, London Bridge, S.E. January and May of each year. London.	Evidence of practical training must be furnished by the Candidate. A. *Preliminary.* English and Arithmetic. Certain Educational Certificates exempt. B. *Technical* (written, oral, and practical). The following subjects as far as they bear upon the duties of a Sanitary Inspector. 1. Elementary Physics and Chemistry in relation to Water, Soil, Air, and Ventilation. 2. Elementary Statistical Methods. 3. Municipal Hygiene or Hygiene of Communities, including Prevention and Abatement of Nuisances, Sanitary Defects in and about Buildings, and their Remedies, Water Supplies, Sanitary Appliances, Drainage, Refuse Removal and Disposal, Offensive Trades, Disinfection, Food Inspection. 4. Statutes, and the Orders, Memoranda, and Model By-laws of the Local Government Board, and the By-laws in force in the Administrative County of London.	£1 1 0 £3 3 0 (Half fees for second attempt.) 21 years and upwards.

3. EXAMINATION FOR SANITARY INSPECTORS OUT OF LONDON

Sanitary Inspectors in the Provinces are usually called Inspectors of Nuisances.

ROYAL SANITARY INSTITUTE, Parkes Museum, London, W. Twice yearly in London; once or more in Edinburgh, Belfast, Manchester and other centres.	Evidence of practical training or of attendance at certain lectures must be furnished by the Candidate. Practical and Theoretical knowledge of the Acts and Model By-laws relating to the duties of Inspector of Nuisances. A knowledge of what constitutes a Nuisance. Inspection of Dwellings, Dairies, Markets, Slaughter-houses, etc., and Nuisances connected with Trades, including Bakehouses, Workshops, Stables, and Offensive Trades. Physical Characteristics of good Drinking Water, and Means of Preventing Pollution. Water Supply. The Characteristics of Good and Bad Food. The Regulations affecting Infectious Diseases. Disinfectants and their Use. Pure Air and the Causes of Deterioration. Principles of Ventilation, and of Good Drainage. Sanitary Appliances for Houses. Inspection of Builders' and Plumbers' work. Drain Testing. Scavenging and the Disposal of Refuse. A Knowledge of the General Duties of the Office, and Methods of Keeping the necessary Books and Records. Writing and Spelling.	£3 3 0 (Half fees for second or third attempt if within two years.) 21 years and upwards.

4. EXAMINATION FOR INSPECTORS OF MEAT AND OTHER FOODS

ROYAL SANITARY INSTITUTE, Parkes Museum, London, W. Twice yearly in London, and once or oftener in Provincial Centres, as chosen for the year.	Candidates must possess Certificate as Sanitary Inspector or Inspector of Nuisances, or Exemption Qualification, must have had training in Meat Inspection, approved by Committee, and must show Testimonials to Personal Character. Subjects of Examination: Laws affecting Inspection and Sale of Meat and other Articles of Food, including Preparation and Adulteration. Disease in Animals for Food, alive and dead. Tuberculin and other Tests. Organs of the body in Animals. Appearance and Character of Fresh Meat, Organs, Fat, Blood, Fish, Poultry, Milk, Fruit, Vegetables, and other Food. The Hygiene of Byres, Lairs, Cowsheds, and Slaughter-houses, and of Markets, Dairies, and other places. Stalling and Slaughtering Animals. Preserving and Storing Meat and other Foods.	£3 3 0 (Half fees for second and third attempt if within two years.) 21 years and upwards.

Group 26
SHOPKEEPING
5

Continued from page 511

METHODS OF BEGINNING BUSINESS

Purchasing an Old Business. Starting a New Business. Partnerships. Goodwill. Terms of Credit. Hire-purchase System.

By W. B. ROBERTSON

THE man who has resolved to rise from the subordinate position of an assistant to the dignity of a shop proprietor has several courses open to him. He may purchase an established business; he may make an independent start and open a new business; he may enter an established concern as a partner, or he may join himself with a partner and set up a new sign.

Purchasing an Old Business. The purchase of an old business must be gone about with circumspection; there are so many pitfalls into which the purchaser may fall. The services of a good commercial lawyer should always be enlisted. The fear of lawyers' charges often deters from such a course, but the risk of being saddled with an apparently sound but really unremunerative business should compel the utilisation of legal advice at every step. Negotiation for the purchase of a business should be preceded by rigorous inquiry into the causes for its disposal. The man who has

the bad as well as the good points of the bargain. These the purchaser must ascertain before the specific money consideration has been decided.

Buying an Old Stock. The longer a retail shop has been established, the greater is the proportion of bad and unsaleable stock with which it is loaded. In establishments where clearing sales have been periodical features, deteriorated stock ought to be very small indeed, but in others where such a plan for turning undesirable merchandise into cash has not been adopted, the accumulations of unsaleable goods often constitute a considerable proportion of the whole stock-in-trade. We have all heard of the tradesman who advertised himself as "Established half a century," and of his rival who capped the announcement with the notice, "Established three weeks—no old stock." In estimating the cost of stock to be taken over, liberal allowance must always be made for deterioration. Usually the transfer is carried out under an arrangement of stock valuation conducted by nominees of the buyer and of the seller, with a referee in cases of disputes. This method is the most satisfactory, but it is also the most expensive. The fees paid for the services of valuers are usually from one to three guineas a day *plus* expenses, and when buyer and seller have each a representative the total charge is high. In every trade there are recognised trade valuers, experts in estimating the cost of goods and fittings, and if one of these conducts the valuation, the result is usually fair and the work not too expensive.

Goodwill. The question of goodwill usually arises in the purchase of a business. Sometimes a goodwill should be paid, but very often the business is not worth it. The question of goodwill should be decided by certain conditions not difficult to ascertain. Let an estimate be taken of the money required to maintain the business upon its existing scale, and let also the probable profit, based upon returns for some years, be gauged. Then let the purchaser or purchasers decide what salary they are entitled to for managerial services. If the balance represent not more than 5 per cent. upon the capital, no goodwill should be paid. Let us take a specific instance. Assume that two men in partnership desire to purchase a business, into which £2,000 must be sunk as price of stock and working capital, and that, based upon the returns of the previous 10 years, the money to be divided between the two annually will be £600. Let us assume further that the services of each partner are worth £200 a year, that they could

salaries from the £600 there would remain £200 for division, or 10 per cent. of the capital invested. It would be proper in such a case to pay something for goodwill, and the amount of goodwill should be estimated upon the excess of profit above 5 per cent., in this case upon £100. The proper amount to be paid as goodwill in a case such as we have taken cannot well be stated. Probably £300 to £500 would be a fair sum, but it would depend upon all the attendant circumstances.

Book Debts. Another detail in the bargaining is the question of book debts; unless, indeed, the business has been entirely cash. The purchaser naturally desires to secure any advantages which may accrue from the collection of debts—the opportunity of seeing and knowing the customers of the shop—but, on the other hand, he wishes to avoid making the bad bargain of purchasing bad and doubtful debts. He may attain both ends by arranging to collect the book debts without charge, but not to purchase them, handing over the money periodically to the vendor after receipt. Then, after six or twelve months have elapsed, the debts remaining unpaid may be handed back to the vendor for collection by any means he may deem desirable. Thus the purchaser may secure the benefit of collecting the accounts from good customers without incurring loss by the defalcations of bad payers, an arrangement which is eminently fair to the vendor.

Partnership. If, instead of purchasing an established business either alone or with a partner, our assistant desires to enter the ranks

of the employers by purchasing a partnership in an existing business, the considerations we have already recited should guide his actions. But to enter a business as a partner often works out badly. We shall assume that our man is imbued with the spirit of enterprise, that he will seek to apply his modern knowledge to the improvement and expansion of the concern with which he has identified himself. If the partner or partners who were there before him acknowledge the need for improvement and the possibility of expansion, and give him scope for the exercise of his energy, all will be well. But if, as is too often the case, the older partners insist that he should crawl in the same narrow path that they have followed, the trouble will have begun, and an inharmonious partnership will result. The man who intends to enter a firm should first of all pass a probationary period as an employee; he should satisfy himself that the policy of the concern is such as he can approve, or, alternately, that there will be no strong opposition to his efforts at modernising it. He should also preserve to himself, if possible, the liberty to withdraw from the partnership after a stipulated time if he finds that he cannot work in harmony with his fellow partners. The conservatism of age and the energy of youthful enthusiasm are often incompatible.

Beginning a New Business. We may now very briefly consider the alternative method of acquiring a right to a shop sign—the starting of a new business instead of the purchase of an old one. It is often the much wiser course. The work is much harder at first, but it pays the right man. He makes his connection instead of buying it, and thus saves the money it would have cost him. He can start with a fresh stock of his own selection, with premises and fixtures to his mind; he is not bound by the legacy of precedent, and he can at once put into practice his ideas of proper business method. Should success attend his efforts, he has also for reward the pride of personal unaided achievement. He can say to himself, "Alone I did it!" And that this is a real gratification will be certified by those who have earned the right to say it.

Cash or Credit? The chief consideration for any novitiate in the ranks of shopkeepers when he is about to determine what business policy he will pursue is that a credit business must have at command much more capital than a cash business. The young man who would establish himself upon the modest savings of his assistantship should choose a neighbourhood where the trade promises to be approximately similar to that to which he has been accustomed, but, other things being equal, he ought to give preference to a place where his turnover will be accounted for by as large a share of cash takings as possible. The advantage of the cash system from the retailer's point of view may be tabulated as follows:

1. The possibility of trading upon a smaller capital.
2. The obviation of loss by bad debts.
3. The absence of bookkeeping and the consequent reduction of working expenses.
4. The greater facility offered of meeting obligations promptly, and thereby of securing better terms.
5. The ability to take advantage of cash bargains that may offer through having cash at command.

Strictly cash terms may be possible in a city thoroughfare where the trade is chiefly casual, but where the connection is a family one in a residential neighbourhood they are impossible. The retailer who refused to depart from them would probably be banished from Suburbia by insolvency. It may be accepted, then, that the usual retail business is one run on both cash and credit lines.

One Price or Two? It must be decided whether the cash and the credit customer should be put upon different terms—if there should be two prices. The tradesman cannot deny to his cash customer a just right to consideration for ready money. He himself will insist upon it in dealing with his merchants. On the other hand, he must take care that his family customers who run accounts should not have it too prominently brought before them that they have to pay for the privilege of an open account. The most suitable system yet devised is that of graduated discounts, say ten per cent. discount for cash, five per cent. discount if the account be paid within one month, and strictly net if longer credit be taken. But on some articles such terms are impossible. They may, under stress of competition, be sold upon less than a ten per cent. margin, so that to sell them under the cash discount mentioned would be to incur a loss on every sale.

A recently introduced method of encouraging a cash trade, and of differentiating between the cash and credit customers, has much to recommend it. Every cash purchaser, of however small an amount, receives a voucher for the amount of his purchase, and when he or she has accumulated vouchers indicating that goods to the value of 20s. have been purchased, they may be exchanged for goods worth 1s. This looks like a five per cent. discount. To the customer it is, but it works out at far less than five per cent. to the retailer. Even if every voucher received were afterwards presented, the discount would be only about three per cent., because the shopkeeper has his profit upon the shilling's worth given for the sovereign's worth of vouchers. Moreover, it is found in practice that not more than sixty per cent. of the vouchers issued are presented for redemption, hence the discount upon the gross cash sales works out at less than two per cent. Another effect of the system is to induce petty customers to patronise the voucher tradesman, so as to add to the number of vouchers, many times when it would otherwise be more convenient to go elsewhere.

One system of trading which should be avoided is that under which retailers issue "trading stamps," or warrants upon independent firms, who exploit the trading-stamp idea to their own

profit. These independent firms must have a profit upon their transactions, and the retailer may retain this profit to himself by following the plan just described.

Hire-purchase System. The hire-purchase system has been making headway in retail commerce, and has become particularly associated with some departments—the trades purveying musical instruments, cycles, furniture, sewing machines, laundry machines, and baby-carriages. Much of the odium that formerly attached to it has disappeared under the examples of the many firms who conduct it upon conditions eminently fair to the customer while profitable to themselves. Into all the intricacies of the system we cannot enter here. The man who would adopt it as a business feature must study the practice of others and the law upon the subject. He may with advantage refer to the book issued by the secretary of the Hire Traders' Protection Association, at 27, Chancery Lane, London, E.C. The form of agreement issued by this association, which is reproduced by permission, embodies the points essential to the enforcement of re-delivery of any goods sold under the system.

The adoption of the hire-purchase system requires the employment of capital which the beginner may lack. If he find that a measure of this system is desirable, he may call in the services of firms who make it their business to take all risks, paying him the cash price whenever the article is delivered and the debt accepted, and taking as their profit the difference between the cash and the instalment price. It is much more profitable for the retailer to shoulder the burden himself, and the instalment agency should be patronised only when funds do not permit of the employment of capital in this branch.

Most retailers who cater for custom under the hire-purchase payments try to secure a first deposit as large as possible. One large London firm insists upon a payment of 25 per cent. before the delivery of the goods; others seem to find the business profitable without any such condition. It is usual to allow the instalments upon larger sums to extend over a longer period than small sums. A good system adopted in the furniture trade is by scale graded as follows:

Value.	Deposit. Per Cent.	Balance in equal payments. Weeks.
£1 to £10	10	20-25
£10 ,, £20	12½	40
£20 ,, £30	15	52
£30 ,, £40	20	78
£40 ,, £50	25	104

Sometimes the period of three years is allowed, but generally this is too long. It may be accepted that a large proportion of those who agree to discharge their liability within two years will not have redeemed their bargains much under three years. The hire-purchase system makes for good quality. Payments cannot well be enforced for articles that have not withstood the wear and tear of the period of instalments, and, as the hirer or purchaser has the right of return, the merchant who sells bad articles will find himself loaded with a stock of surrendered merchandise.

Memorandum of Agreement made the

day of 190 between

of

hereinafter called the Owner, of the one part, and

of

hereinafter called the Hirer, of the other part.

Witnesseth that the Owner agrees to let, and the Hirer agrees to hire, the goods mentioned at the side hereof belonging to the Owner, upon the terms and conditions following:—

1 The Hirer to pay the sum of £ on signing this Agreement (in consideration of the option of purchase herein granted) and for which credit will only be given in the event of the hirer purchasing the said goods.

2 The Hirer shall punctually pay to the Owner without previous demand the rent of for the hire of the said goods commencing with the day of

3 In case the said rent shall be in arrear more than seven days, or in case the Hirer commit any breach of this Agreement, or suffer any breach to be committed, the Owner shall thereupon be entitled to take and resume possession of the said goods and for that purpose full power and liberty are hereby given to the Owner, his servants, and agents, to enter into any house or buildings of which the Hirer may be, or appears to be, tenant and there to search for and retake the said goods without any resistance on the part of the Hirer, his relatives, friends or servants.

4 The Hirer will keep the said goods in good order and repair, damage by fire included, but fair wear and tear excepted.

5 The Hirer shall not remove or suffer the said goods to be removed without the Owner's permission, and shall keep the said goods free and exempt from all legal process.

6 The Hirer may terminate the hiring by delivering up to the Owner the said goods in good order and condition, and thereupon this agreement shall be void, subject nevertheless to the rights of the Owner in respect of rent and damages (if any) accrued previously to the delivering up of the said goods.

7 Upon punctual payment of rent as aforesaid amounting to the full sum of £ the said goods shall become the absolute property of the Hirer freed from payment of all further rent, but until payment of the said sum the Hirer shall remain Bailee only of the said goods.

8 Any relaxation or indulgence which the Owner may show to the Hirer shall not in any way prejudice his strict rights under this agreement.

Signature

Witness

SIXPENNY STAMP IF £5 OR UPWARDS

[COPYRIGHT.]

HIRE-PURCHASE AGREEMENT ISSUED BY HIRE TRADERS' PROTECTION ASSOCIATION

The Keeping of all Kinds of Shops. The scheme of this course includes practical articles on every department of shopkeeping Such branches as are allied to one or other of the more important trades will be treated separately, so that the articles will be a guide to the adoption of side-line departments as well as to the establishment of independent shops. The articles begin in Part 6 of the SELF-EDUCATOR.

Continued

VULGAR FRACTIONS

Division of Fractions. Continued Fractions. Expression of Decimals as Vulgar Fractions. Fractions of Concrete Quantities. Examples

Group 21
MATHEMATICS
5

Continued from page 548

By HERBERT J. ALLPORT, M.A.

83. Division of Fractions. (i.) When the divisor is a whole number.

Suppose we have to divide $\frac{7}{9}$ by 4.

We know $\frac{7}{9} = \frac{28}{36}$. This fraction means that the unit is divided into 36 equal parts, and 28 of the parts taken. If we divide the 28 parts by 4, we get 7 of them—*i.e.* $\frac{7}{36}$. Hence $\frac{7}{9} \div 4 = \frac{7}{36}$.

Therefore, *to divide a fraction by a whole number, we multiply the denominator by that number.*

In the same way as already explained for multiplication, we cancel any common factors contained in the divisor and the numerator. Hence, if the numerator be exactly divisible by the divisor, we may *divide a fraction by a whole number by dividing the numerator by that number.*

Example 1. $\frac{27}{31} \div 18 = \frac{\cancel{27}^{\,3}}{31 \times \cancel{18}_{\,2}} = \frac{3}{62}$ *Ans.*

Example 2. $\frac{36}{41} \div 9 = \frac{4}{41}$ *Ans.*

(ii.) When the divisor is a fraction.

In the operation $24 \div 3$, we have to find the number which, when multiplied by 3, will give 24. Similarly, to find the value of $\frac{3}{7} \div \frac{5}{9}$ we have to find the fraction which, when multiplied by $\frac{5}{9}$, will give $\frac{3}{7}$.

But $\frac{3 \times 9}{7 \times 5}$ is the fraction which gives $\frac{3}{7}$ when multiplied by $\frac{5}{9}$. Therefore, $\frac{3}{7} \div \frac{5}{9} = \frac{3 \times 9}{7 \times 5}$.

Hence, *to divide by a fraction, invert the divisor and multiply.*

As in multiplication, mixed numbers must first be reduced to improper fractions.

Example 3. Divide $3\frac{1}{14}$ by $5\frac{5}{42}$.

$$3\tfrac{1}{14} \div 5\tfrac{5}{42} = \frac{43}{14} \div \frac{215}{42} = \frac{\cancel{43}}{\cancel{14}} \times \frac{\cancel{42}^{\,3}}{\cancel{215}_{\,5}} = \frac{3}{5}\ \textit{Ans.}$$

84. Brackets. Brackets are symbols used to join together two or more quantities, to indicate that they are to be treated as a single quantity.

Thus, $(3\frac{1}{2} - 1\frac{1}{8}) \div 2\frac{3}{4}$ means that $1\frac{1}{8}$ is to be subtracted from $3\frac{1}{2}$, and the result divided by $2\frac{3}{4}$. The value of this expression is, therefore,

$$2\tfrac{3}{8} \div 2\tfrac{3}{4} = \tfrac{19}{8} \times \tfrac{4}{11} = \tfrac{19}{22}.$$

Without the brackets, the value would be

$3\frac{1}{2} - \frac{9}{8} \div \frac{11}{4} = 3\frac{1}{2} - \frac{9}{8} \times \frac{4}{11} = 3\frac{1}{2} - \frac{9}{22} = 3\frac{1}{11}$.

It is necessary to have several shapes for brackets, such as ( ), { }, [ ], since parts of an expression we wish to treat as a single quantity may already be enclosed in brackets.

Example. Find the value of

$$\left[\left\{(\tfrac{1}{2} + \tfrac{1}{3}) \div (\tfrac{1}{4} + \tfrac{1}{5})\right\} - 1\tfrac{4}{9}\right] \div (1\tfrac{1}{9} - \tfrac{19}{27}).$$

Given expression

$$= \left[\left\{\frac{5}{6} \div \frac{9}{20}\right\} - 1\tfrac{4}{9}\right] \div \frac{30 - 19}{27},$$

$$= \left[\left\{\frac{5}{\cancel{6}_{\,3}} \times \frac{\cancel{20}^{\,10}}{9}\right\} - 1\tfrac{4}{9}\right] \div \frac{11}{27},$$

$$= [1\tfrac{23}{27} - 1\tfrac{4}{9}] \div \frac{11}{27},$$

$$= \frac{23 - 12}{27} \div \frac{11}{27},$$

$$= \tfrac{11}{27} \times \tfrac{27}{11} = 1\ \textit{Ans.}$$

Note that we first simplify the expressions in the innermost brackets, then proceed to the next inner bracket, and so on.

85. We have, so far, only considered fractions in which both the numerator and the denominator are integers. These are called *Simple Fractions.*

A *Complex Fraction* is one in which the numerator or denominator, or both, are fractions.

Thus $\frac{3\frac{1}{2}}{2\frac{3}{8}}$, $\frac{1}{\frac{5}{6} \times \frac{3}{4}}$, $\frac{1\frac{2}{7}}{8}$, are complex fractions.

Now, to divide a unit into 5 equal parts and take 3 of them gives the same result as dividing 3 units into 5 parts and taking one of them—*i.e.*, $\frac{3}{5}$ represents the quotient of 3 divided by 5.

Hence $\frac{\frac{5}{16}}{\frac{15}{24}}$ means $\frac{5}{16} \div \frac{15}{24}$.

Therefore, to simplify a complex fraction reduce both numerator and denominator to simple fractions, and divide the one by the other.

Example 1. Simplify $\frac{2\frac{1}{4} - 1\frac{5}{6} + 3\frac{3}{8}}{1\frac{1}{2} \div \frac{6}{13}}$.

Given expression

$$= \frac{4 + \dfrac{6 - 20 + 9}{24}}{\dfrac{\cancel{3}}{2} \times \dfrac{13}{\cancel{6}_{\,2}}} = \frac{3 + \dfrac{39 - 20}{24}}{\dfrac{13}{4}}$$

$$= 3\tfrac{19}{24} \div \frac{13}{4} = \frac{\cancel{91}^{\,7}}{\cancel{24}_{\,6}} \times \frac{\cancel{4}}{\cancel{13}} = \frac{7}{6} = 1\tfrac{1}{6}\ \textit{Ans.}$$

Example 2. Find the value of

$$\frac{\frac{1}{3}+\frac{1}{4}+\frac{1}{5}}{\frac{1}{2\frac{1}{3}}+\frac{1}{3\frac{1}{4}}+\frac{1}{4\frac{1}{5}}}.$$

Given expression

$$=\frac{\frac{20+15+12}{60}}{\frac{1}{\frac{7}{3}}+\frac{1}{\frac{13}{4}}+\frac{1}{\frac{21}{5}}}=\frac{\frac{47}{60}}{\frac{3}{7}+\frac{4}{13}+\frac{5}{21}}$$

$$=\frac{\frac{47}{60}}{\frac{117+84+65}{273}}$$

$$=\frac{47}{60}\div\frac{266}{273}=\frac{47}{\underset{20}{\cancel{60}}}\times\frac{\overset{\overset{13}{\cancel{91}}}{\cancel{273}}}{\underset{38}{\cancel{266}}}=\frac{611}{760}\ \textit{Ans.}$$

86. A *Compound Fraction* is a fraction of a fraction.

Thus, $\frac{3}{5}$ of $\frac{4}{7}$ is a compound fraction.

To obtain $\frac{3}{5}$ of $\frac{4}{7}$ we have to divide $\frac{4}{7}$ into 5 equal parts and take 3 of them. But $\frac{4}{7} \div 5 = \frac{4}{35}$. And three of these parts $= 3 \times \frac{4}{35} = \frac{12}{35}$.

Hence $\frac{3}{5}$ of $\frac{4}{7} = \frac{12}{35}$; which is also the value of $\frac{3}{5} \times \frac{4}{7}$.

Therefore, the word "of" has the same meaning as $\times$.

87. *In expressions where additions and subtractions as well as multiplications and divisions occur, the multiplications and divisions must be performed before the additions and subtractions.*

Thus $\frac{3}{4} \div \frac{7}{8} + \frac{2}{3}$ means that $\frac{3}{4}$ is to be divided by $\frac{7}{8}$, and $\frac{2}{3}$ is to be added to the result.

It does not mean that $\frac{3}{4}$ is to be divided by the result obtained when we add $\frac{2}{3}$ to $\frac{7}{8}$. This would be represented by $\frac{3}{4} \div (\frac{7}{8} + \frac{2}{3})$.

In such expressions as $\frac{1}{4} \div \frac{3}{8} \times \frac{5}{9}$, each of the symbols $\times$, $\div$, refers only to the fraction immediately following it.

Thus $\quad \frac{1}{4} \div \frac{3}{8} \times \frac{5}{9} = \frac{1}{4} \times \frac{8}{3} \times \frac{5}{9} = \frac{10}{27}.$

But, if the above expression were written $\frac{1}{4} \div \frac{3}{8}$ of $\frac{5}{9}$ it would mean that $\frac{3}{8}$ of $\frac{5}{9}$ is to be treated as a single quantity, and the value would be $\frac{1}{4} \div (\frac{3}{8} \times \frac{5}{9}) = \frac{1}{4} \div \frac{15}{72} = \frac{1}{4} \times \frac{72}{15} = \frac{6}{5} = 1\frac{1}{5}$.

88. Continued Fractions. A fraction of the following form is called a *Continued Fraction*.

$$\cfrac{1}{2+\cfrac{1}{5+\cfrac{1}{3+\cfrac{2}{1+\frac{5}{6}}}}}$$

To simplify it, we begin at the lowest line. Thus, the given fraction

$$=\cfrac{1}{2+\cfrac{1}{5+\cfrac{1}{3+\cfrac{2}{\frac{11}{6}}}}}=\cfrac{1}{2+\cfrac{1}{5+\cfrac{1}{3+\frac{12}{11}}}}$$

$$=\cfrac{1}{2+\cfrac{1}{5+\frac{11}{45}}}=\cfrac{1}{2+\frac{45}{236}}$$

$$=\frac{236}{517}\ \textit{Ans.}$$

EXAMPLES 10

Arrange in order of magnitude, writing the least first:

1. $\frac{8}{21}$, $\frac{13}{35}$, $\frac{11}{28}$.

2. $\frac{81}{95}$, $\frac{46}{57}$, $\frac{97}{114}$, $\frac{31}{38}$.

3. $\frac{23}{222}$, $\frac{31}{322}$, $\frac{41}{399}$.

Find the value of

4. $3\frac{4}{7} + 1\frac{3}{5} + \frac{13}{21} + 5\frac{4}{15}$.

5. $\frac{13}{60} + 4\frac{5}{42} - 2\frac{7}{60}$.

6. $3\frac{2}{3} - 4\frac{3}{4} + 5\frac{4}{5} - 6\frac{5}{6} + 7\frac{6}{7}$.

7. $\frac{117}{143} - \frac{13}{209} + \frac{57}{253}$.

8. $\frac{1}{8}$ of $\frac{3}{14}$ of $5 - \frac{4}{7}$ of $\frac{2}{5}$ of $\frac{3}{4}$.

9. $(2\frac{1}{2}$ of $4\frac{3}{4} - 3\frac{5}{12}) \div (\frac{5}{6} + \frac{4}{5}$ of $3\frac{1}{3})$.

10. $6\frac{7}{8} \times 3\frac{9}{11} - 7\frac{1}{16} \div 5\frac{11}{45} - 4\frac{1}{2} \times 5\frac{5}{16}$.

11. $\left\{\frac{2}{7} + (5\frac{1}{2} + 3\frac{1}{8}) \text{ of } \frac{19}{23}\right\} \div \left\{8\frac{5}{7} - (4\frac{8}{9} \div \frac{5}{9} \text{ of } 5\frac{1}{2})\right\}$.

12. $\dfrac{2\frac{1}{2}+3\frac{5}{6}}{5\frac{1}{3}-4\frac{1}{4}} \times \dfrac{12\frac{2}{7} \text{ of } 13\frac{7}{8}}{9\frac{1}{4} \text{ of } 6} \div \dfrac{(7\frac{1}{2}-\frac{3}{4} \text{ of } \frac{8}{9}) \div 8\frac{1}{5}}{(10\frac{5}{8}-2\frac{3}{8} \text{ of } 4) \div 3\frac{2}{7} \text{ of } 7\frac{1}{2}}$.

13. $\cfrac{10}{3-\cfrac{1}{1-\cfrac{2}{3+\frac{2}{7}}}}$

14. $\cfrac{1}{3+\cfrac{1}{2+\cfrac{1}{5+\frac{1}{4}}}} \times \cfrac{1}{1+\cfrac{1}{3+\cfrac{1}{3+\frac{1}{3}}}}$

15. $3\frac{1}{3} - \cfrac{1}{2-\cfrac{1}{3-\cfrac{1}{2-\cfrac{1}{1-\cfrac{1}{3+\frac{1}{3}}}}}}$

89. Expression of Decimal Fractions as Vulgar Fractions.

Example. Express 5·375 as a vulgar fraction.

$\cdot 375 = 375$ thousandths.

Therefore, $\therefore 5\cdot375 = 5\frac{375}{1000} = 5\frac{3}{8}$ *Ans.*

Hence, the rule is: Take the digits of the decimal for numerator; for the denominator

put down 1 followed by as many noughts as there are digits in the decimal. Reduce this fraction to its lowest terms.

90. Expression of Vulgar Fractions as Decimals.

We have seen [Art. 85] that a vulgar fraction represents the quotient of the numerator divided by the denominator. Therefore, to convert a vulgar fraction to a decimal fraction, we divide the numerator by the denominator.

The process is, in fact, the same as that already explained in Art. 33.

Example. Express $\frac{3}{32}$ as a decimal.

$$\begin{array}{l} 4)\underline{3\cdot0} \\ 8)\underline{\ \cdot75} \\ \quad \underline{\cdot09375}\ \textit{Ans.} \end{array}$$

Use factors of 32, and proceed as in Ex. 1, Art. 33.

It will be found in many cases that there is always a remainder, so that the quotient can be continued indefinitely. [Ex. 2, Art. 33.]

FRACTIONS OF CONCRETE QUANTITIES

91. From the definition of a vulgar fraction, it is clear that to obtain any required fraction of a given compound quantity we divide by the denominator of the fraction and multiply the result by the numerator.

Example 1. Find the value of $\frac{7}{9}$ of £3 17s. $4\frac{1}{2}$d.

$$\begin{array}{rrrl} & \text{£} & \text{s.} & \text{d.} \\ 9) & 3 & 17 & 4\frac{1}{2} \\ \hline & & 8 & 7\frac{1}{6}\ * \\ & & & 7 \\ \hline & \text{£}3 & 0 & 2\frac{1}{6}\ \textit{Ans.} \end{array}$$

* After dividing the pence by 9, there is a remainder $1\frac{1}{2}$d. $= \frac{3}{2}$d. and $\frac{3}{2} \div 9 = \frac{3}{18} = \frac{1}{6}$.

Example 2. Find the value of $4\frac{3}{8}$ of £6 18s 2d.

$$\begin{array}{rrrl} & \text{£} & \text{s} & \text{d.} \\ 8) & 6 & 18 & 2 \\ \hline & & 17 & 3\frac{1}{4} = \frac{1}{8} \text{ of £6 18s. 2d.} \\ & & & 3 \\ \hline & 2 & 11 & 9\frac{3}{4} = \frac{3}{8} \text{ of £6 18s. 2d.} \\ & 27 & 12 & 8 \ \ = 4 \times \text{£6 18s. 2d.} \\ \hline & \text{£}30 & 4 & 5\frac{3}{4}\ \textit{Ans.} \end{array}$$

To obtain the value of a given *decimal* fraction of a concrete quantity, we may reduce the decimal to a vulgar fraction and proceed as above.

Or, we may adopt the method shown in the following examples.

Example 3. Find the value of 2·13625 of £5.

$$\begin{array}{rl} 2\cdot13625 \text{ of £5} = & \text{£}10\cdot68125 \\ & \underline{\quad 20} \\ & 13\cdot62500 \text{ s.} \\ & \underline{\quad 12} \\ & 7\cdot500 \text{ d.} \\ & \underline{\quad 4} \\ & 2\cdot0 \quad \text{far} \\ & \text{£}10\ \ 13\text{s.}\ \ 7\tfrac{1}{2}\text{d.}\ \textit{Ans.} \end{array}$$

Explanation. Multiply 2·13625 by 5. Multiply *the decimal part* of the product by 20 to reduce it to shillings. Multiply the decimal part of the shillings by 12 to reduce it to pence; and so on.

Example 4. Find the value in lb. and decimal of a lb. of ·0123 of 3 tons 5 cwt. 47 lb.

$$\begin{array}{r} 3 \text{ tons } 5 \text{ cwt. } 47 \text{ lb.} \\ \underline{20} \quad\quad\quad\quad \\ 65 \text{ cwt.} \quad\quad \\ \underline{112} \quad\quad\quad\quad \\ 607 \quad\quad\quad\quad \\ 672 \quad\quad\quad\quad \\ \hline 7327 \text{ lb.} \quad\quad \\ \underline{\cdot0123} \quad\quad \\ 73\cdot27 \quad\quad \\ 14\cdot654 \quad\quad \\ \underline{2\cdot1981} \quad\quad \\ \underline{90\cdot1221 \text{ lb. } \textit{Ans.}} \end{array}$$

Reduce the tons, etc., to lb. and take ·0123 of the result.

92. The converse of this operation is to find by what fraction (vulgar or decimal) we must multiply one given quantity to produce another given quantity.

Example 1. *What fraction of* 2 *tons* 7 *cwt.* 2 *qrs. is* 1 *ton* 8 *cwt.* 2 *qrs.?*

Express each of the quantities as simple quantities in terms of the same unit.

Thus, 2 tons 7 cwt. 2 qrs. = 190 qrs.
and 1 ton 8 cwt. 2 qrs. = 114 qrs.

Hence 1 ton 8 cwt. 2 qrs. is evidently $\frac{114}{190}$ of 2 tons 8 cwt. 2 qrs.—

i.e., Required fraction $= \frac{114}{190} = \frac{3}{5}$ *Ans.*

We therefore have the following rule. To express one compound quantity as the fraction of another of the same kind, reduce the quantities to terms of the same unit; take the first quantity for numerator and the second for denominator.

Example 2. Reduce £7 3s. $2\frac{3}{4}$d. to the decimal of £5 4s. 2d.

$$\begin{array}{rrr} \text{£} & \text{s.} & \text{d.} \\ 7 & 3 & 2\frac{3}{4} \\ \underline{20} & & \\ 143 & \text{s.} & \\ \underline{12} & & \\ 1718 & \text{d:} & \\ \underline{4} & & \\ 6875 & \text{far.} & \end{array} \qquad \begin{array}{rrr} \text{£} & \text{s.} & \text{d.} \\ 5 & 4 & 2 \\ \underline{20} & & \\ 104 & \text{s.} & \\ \underline{12} & & \\ 1250 & \text{d} & \\ \underline{4} & & \\ 5000 & \text{far.} & \end{array}$$

Here we reduce the two amounts to farthings, and divide the first by the second.

$$\begin{array}{r} 5\cdot000)6\cdot875 \\ \underline{1\cdot375\ \textit{Ans.}} \end{array}$$

93. Miscellaneous Questions Involving Fractions.

Example 1. In a cricket match, one man made $\frac{1}{3}$ of the total runs; another man made $\frac{1}{3}$ of the remainder. These two scores differed by 7; what was the total?

First man made $\frac{1}{3}$ of the total.

Second man made $\frac{1}{3}$ of the remainder, $= \frac{1}{3}$ of $\frac{2}{3}$ of the total $= \frac{2}{9}$ of the total. Therefore, difference between their scores $= (\frac{1}{3} - \frac{2}{9})$ of the total $= \frac{3-2}{9} = \frac{1}{9}$ of the total.

Hence, 7 runs is $\frac{1}{9}$ of the total: so that the total $= 7 \times 9 = 63$ runs *Ans.*

Example 2. In paying two bills, one of which exceeds the other by $\frac{1}{3}$ of the less, the change out of a £5 note is half the difference of the bills. What are the two amounts ?

Difference between the bills $= \frac{1}{3}$ of smaller bill.

And, change out of £5 $= \frac{1}{2}$ difference between the bills $= \frac{1}{2}$ of $\frac{1}{3}$ of smaller $= \frac{1}{6}$ of smaller.

But, the larger bill equals $1\frac{1}{3}$ times the smaller. Therefore, since the two bills and the change make £5, we have

$(1\frac{1}{3} + 1 + \frac{1}{6})$ of the smaller bill $=$ £5;

i.e., $2\frac{1}{2}$ times the smaller $=$ £5.

Therefore,

$$\left.\begin{array}{l}\text{Smaller bill} = \dfrac{£5}{2\frac{1}{2}} = \dfrac{£5 \times 2}{5} = £2 \\ \text{and} \\ \text{Larger bill} = £2 + \frac{1}{3} \text{ of } £2 = £2\ 13s.\ 4d.\end{array}\right\} \underline{\textit{Ans.}}$$

Example 3. For one-third of a mile a submarine cable is laid overland, $\frac{1}{12}$ of it is suspended in the water, $\frac{219}{240}$ lies on the bed of the sea. Find its length.

The fraction of the cable laid overland is evidently $(1 - \frac{1}{12} - \frac{219}{240})$ of its length.

$$= \frac{240 - 20 - 219}{240} = \frac{1}{240} \text{ of its length.}$$

$\therefore \frac{1}{240}$ of its length $= \frac{1}{3}$ of a mile.

Hence, total length $= \frac{240}{3} =$ <u>80 miles *Ans.*</u>

EXAMPLES 11

1. Reduce the difference between $\frac{1}{7}$ of $\frac{5}{12}$ of a guinea and ·128 of £1 to the decimal of half-a-crown.

2. Express $\frac{2\cdot5}{\cdot375} \times \frac{4\cdot55}{3\frac{1}{4}}$ of an hour in minutes.

3. A sum of money is divided amongst three men, so that the first has $\frac{1}{4}$ of it, the second has $\frac{2}{3}$ and the third has 38s. What is the sum ?

4. A boy sold his knife for half-a-crown and gained a quarter of what it cost him. For how much should he have sold it to gain a quarter of the selling price ?

5. A man left £450 to his youngest son, $\frac{3}{8}$ of his money to his second son, and to his eldest son he left as much as to the other two together. How much money did he leave altogether ?

6. Three brothers have a sum of money divided amongst them so that each has $\frac{5}{6}$ of what his next eldest brother has. The eldest has £73 2s. 6d. more than the youngest. Find the sum of money.

7. What decimal of $\frac{3}{7}$ of $2\frac{1}{12}$ of £2 is equal to ·65375 of £17 − 14·295 crowns ?

8. In walking from one town to another, a man finds that at two o'clock he has completed $\frac{1}{4}$ of his journey, and at 2.15 he has completed $\frac{1}{3}$. At what time will he reach his destination ?

9. A woman had a certain number of oranges. She sells A half of them and one more, to B she sells half the remainder and one more, to C she sells half the new remainder and one more, and she now sells one more than half of what she has left to D. She has three oranges left. How many had she at first ?

10. At a point of his journey from one place to another, a man noticed that $\frac{4}{5}$ of the distance he had already travelled was $\frac{1}{2}$ the distance he still had to go. After another $2\frac{1}{4}$ miles he had just completed half his journey. How many miles had he still to go when he made the first observation ?

Answers to Arithmetic

Examples 1

1. 770904. 2. 395504. 3. 9712. 4. No. of third class = 389 − 177 = 212; No. of second class = 389 − 262 = 127; No. of first class = 177 − 127 = 50. 5. (*a*) 4236705; (*b*) 2494851612. 6. He sells 129 sheep for 7s. each more than they cost. Gain on these = 129 × 7 = 903s. He sells 82 sheep at a loss of 3s. each. Loss on these = 82 × 3 = 246s. On the whole, he gains 903 − 246 = 657s. 7. (*a*) 14403; (*b*) 1141 quo. 505 rem.; (*c*) 608379 quo. 196126 rem. 8. Total gain = £840 − £720 = £120. Gain on each animal = £2. ∴ No. of animals = 120 ÷ 2 = 60. ∴ Price he paid for each animal = £720 ÷ 60 = £12. 9. To give the first boy 2, the second 3, and the third 4, requires 2 + 3 + 4 = 9 marbles. Since 270 ÷ 9 = 30, the first boy can therefore have thirty 2's, the second thirty 3's, the third thirty 4's — *i.e.*, 60, 90, 120, respectively. 10. 1 lb. of coffee is worth 18 ÷ 3—*i.e.*, 6 lb. sugar. ∴ 82 lb. are worth 82 × 6 = 492 lb. sugar.

Examples 2

1. 659·71012. 2. 141·23571. 3. (*a*) 6·58476; (*b*) 677·97647. 4. (*a*) 4·2167; (*b*) 588·411. 5. (*a*) 23705·5; (*b*) 5·563296; (*c*) ·1443532. 6. (*a*) 518·4256; (*b*) 1·29519. 7. (*a*) ·0203704; (*b*) 34·6469090 . . .; (*c*) ·316. 8. (*a*) ·02579; (*b*) 575·65. 9. (*a*) 6·88; (*b*) ·0601; (*c*) ·001963; (*d*) 6000. 10. (*a*) 120000; (*b*) 2·73665; (*c*) 4725. 11. We have to divide 463 hundredths into 36419·85 hundredths. The quotient is 78, and remainder 305·85 hundredths—*i.e.*, 3·0585. Thus, the subtraction can be done 78 times, and the remainder is 3·0585. 12. 58921·09175. 13 37·5025. 14. 280·03. 15. 3. 16. 60000.

Examples 3

1. 291911. 2. 46125. 3. 6241852. 4. 47380. 5. 120921. 6. 484347. 7. 1691. 8. 4275. 9. 2171. 10. 467. 11. 11237. 12. 128268. 13. 51799. 14. 495780. 15. 2008800. 16. 13188. 17. 1757. 18. 163539. 19. 1079822. 20. 26651. 21. 27477. 22. 1190274. 23. 14664. 24. 224028. 25. 37524. 26. 3671316. 27. 185337. 28. 75727. 29. 263970. 30. 9331200. 31. 232. 32. 494. 33. 15. 34. 3716.

[The answers to Examples 4—11 appear in Part 6 of the SELF-EDUCATOR.]

NOTE: In Examples 7, No. 13, page 230, for £29 15s. read £29 5s.

Continued

OPERATIONS IN FIELD SURVEYING

Including Tacheometrical and Plane Table Surveying. Finding the True North. The Magnetic Needle

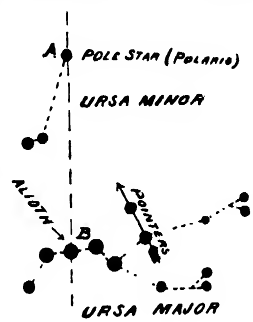
Continued from page 594

By Professor HENRY ROBINSON

Declination or Variation of the Magnetic Needle. This is the horizontal angle that the compass-needle makes with the true meridian, and is never a constant quantity. The value of the variation of the needle is given every year in "Whitaker's Almanac." It is necessary to obtain the value of the angle due to the variation of the needle when plans are being plotted to "true" north, in order that corrections may be made to the compass readings which are taken in the field, and from which the plan is being plotted.

The daily variation in the declination of the needle consists in a swinging of the needle through an arc of about 8 in., the north end having its extreme easterly variation about 8 a.m., and its extreme westerly variation about 1.30 p.m., the mean declination taking place about 10.30 a.m. and 8 p.m.

To Find the True North. The meridian of a station on the earth's surface is a great circle passing through the North and South Poles, and through the station. The inter-section of this circle with the sensible horizon of the observer is called a meridian line, and marks the north and south points of his horizon. This, of course, varies according to the geographical position of the observer. A method of finding the line of meridian by the sun has already been explained when dealing with "Chain Surveying." Another method is that known and is



the telescope of a theodolite, and carefully level the instrument. Observe the sun at some distance to the east of the meridian an hour or two before noon, as about noon the motion of the sun is nearly parallel to the horizon. In this position, take the reading on the horizontal scale of the instrument, the vertical arc being securely clamped. When the sun has passed the meridian and is descending in the west, turn the telescope so as to ...t it, the vertical arc still being clamped.

evident that the altitude is precisely the same as that observed before noon. Take the reading on the horizontal scale, then the difference between this and the reading taken before noon will be the *azimuthal*, or horizontal arc, described by the sun in the interval between the two observations.

Herschel describes the *azimuth* as the angular distance of a celestial object from the north or south point of the horizon, according as it is the north or south pole of the horizon which is elevated, when the object is referred to the horizon by a vertical circle.

It is evident that when the altitudes of the sun—or of a star—are equal on either side of the meridian, its azimuths or bearings, whether reckoned both from the north or both from the south point of the horizon, must also be equal. Consequently, a line through the north and south points of the horizon will bisect the horizontal arc thus determined, and may therefore be marked on the ground.

Allowance for the Sun's Deflection. In observing the sun very accurately, either its upper or lower limb should be taken. If much time elapses between the observations, a correction must be applied to compensate for the change in the sun's declination during the interval.

From mid-winter to mid-summer the sun gradually approaches the North Pole, and consequently a shorter period will intervene between ascending from a certain altitude to the meridian to descending from the meridian to a similar altitude on the other side (which is in northern latitudes). The reverse takes place from mid-summer to mid-winter. The change of declination is given for every hour in the "Nautical Almanac."

Another simple method is by

Alioth, which is one of the combination known as the Great Bear (*Ursa Major*) [48].

It is known that these stars pass the meridian within about nine minutes of each other. The method of obtaining the meridian from these stars is as follows: Suspend two plummets by fine thread at the end of a rod exactly between the star Alioth (B) and the eye when the former is nearing the meridian. Then, at the moment the pole star (A) is also seen along the two plumb lines, they will be nearly in the plane of the meridian, which is then fixed.

It is now proposed to give some information with regard to a few instruments that are used in connection with the work for purposes of rapid field-work.

The most usual method has been to fix the positions of points on a plan by means of the

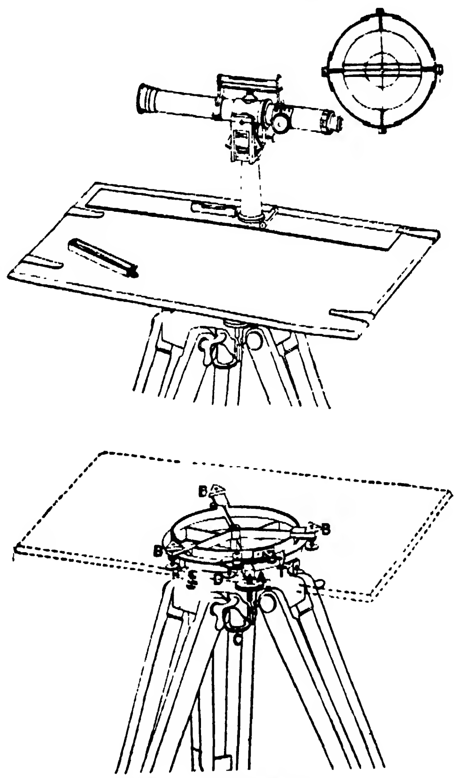
theodolite and chain, whilst their differences of vertical height have been obtained by the level. In recent years the theodolite has come into prominence on account of the accuracy that can be obtained in arriving at the differences of level of places by means of the vertical circle of the instrument, while at the same time the direction and position of points with regard to one another may be fixed by readings to an ordinary level-staff.

Another form of theodolite used for this purpose is the *Tachometer*, which is really a transit theodolite provided with "stadia" hairs and a special lens, which makes the principal inside focus of the object-glass coincide with the vertical axis of the instrument. This construction enables distances to be directly computed from the station at which the instrument is placed without the necessity of making any allowance for the focal distance falling outside the central axis, as would have to be done were the stadia hairs placed in an ordinary theodolite. The *Omnimeter* is another form of instrument for reading distances direct.

The Plane Table. The *Plane Table* is another means by which surveys may be rapidly made and plotted in the field as the work proceeds.

It is now proposed to give a brief description of the various means of surveying by the foregoing methods.

The plane table is an instrument which has not been much employed in this country, owing chiefly to the uncertainty of the climate, but abroad its use has yielded excellent results, and the various parts have been developed in order to make it more accurate. In its simplest form it consists of a plain drawing-board (on which drawing-paper is fixed) about 2 ft. square, mounted on a firm tripod, and provided with a flat rule, or "alidade," as it is termed, with a sight vane at each end, by means of which sights are taken to the required points.



44. PLANE TABLE

A compass, in a small metallic box, is used for fixing the meridian line on the paper. Abroad, this simple form of alidade has been very much improved, and means have also been introduced to enable the table to be levelled. Instead of the sight-vanes, the alidade is provided with a telescope with cross hairs for measuring the distances.

An enlargement of these hairs is shown at the side of the illustration [**44**]. The lower part of the illustration shows the arrangement of levelling screws.

The three triangular plates BBB are let in the under-side of the board, and the support is screwed into them. The table is then levelled by means of three screws, of which one (A) is shown. When this is done, the lower part of the support is clamped by the screw C. The clamp screw D and the tangent screw T are used to fix the upper part of the board either to the meridian by means of the compass, or to any desired line of sight to which the board is to be directed.

Using the Plane Table. The general method of procedure is as follows: [**45**]

A base line is first chained on the ground as AB, the plane table is set up over station A, and the position of A is marked on the paper at any convenient point to suit the various points of the survey to be obtained later. A plumb-bob should be provided, fitted to a clamp to fix to the table, for getting accurately the position of the station on the paper.

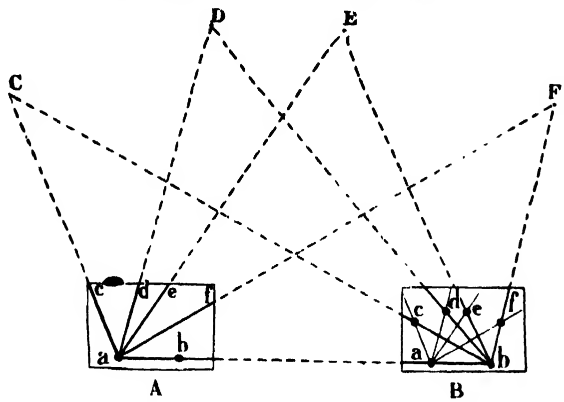
Having fixed the position A, the compass is placed on the paper and moved about until the needle becomes stationary to the north. Lines are then drawn round the box in order that the meridian line may again be used at any other station as a check. The edge of the ruler—called the *fiducial* edge—is now placed at the point a, which corresponds to A on the ground, and the ruler is moved until B is sighted. The line a b is then drawn, and its measured distance scaled off on this line. Any other required directions, as C, D, E, and F, are now sighted in the same way, care being taken to mark the lines for verification. The table is then moved to B, the alidade is placed along a b, and the table is moved until the point a is sighted. The directions from b to C, D, E and F are then sighted, and the lines drawn, their intersection points will then give the positions of these places on the plan. As in the case of the *Station Pointer*, which is explained elsewhere, care must be taken to avoid the adoption of a point in which the position of the table and the objects to be located are on the circumference of a circle, as under these conditions correct fixing is impossible.

Tacheometrical Surveying. It is impossible in the space allotted to this portion of

the work to describe every form of instrument used in the locating of points by angular measurement, commonly called *tacheometry*. This part of the subject will, however, be dealt with by the employment of the theodolite and by the tacheometer.

In the first case, readings are taken to two known points on a level-staff, whilst in the second case hairs are placed in the diaphragm of the telescope (called "stadia" hairs). The number of divisions on a level-staff that are intersected by these hairs gives the distance of the staff from the instrument, provided the telescope be truly horizontal, and the staff vertical.

In the event of the telescope being elevated, or depressed, some modification is required, for reasons which will be explained.

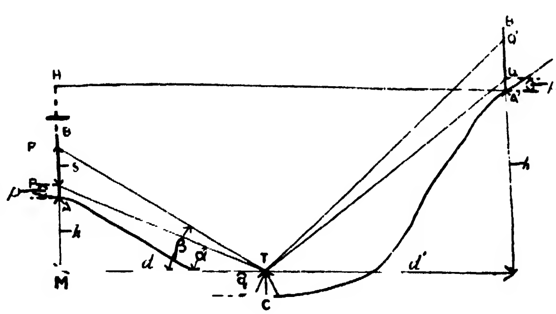


45. SURVEY WITH PLANE TABLE

If the student is desirous of going more deeply into the subject, the work of Mr. Kennedy on "Surveying with the Tacheometer," or a paper by Mr. Wilfrid Airy in the "Proceedings of the Institution of Civil Engineers," will be found valuable.

The position of the main survey lines must be fixed by traversing, or by triangulation, as we have already explained. The directions of the points may be fixed either by taking their bearings, or by their angles with some known point. In surveying by vertical angles, readings are taken to known portions of the level-staff giving a base preferably of 10 ft.—that is, by taking the readings at 2 and 12 ft. on the staff.

In the illustration [46], let PP^1 be two well-defined points on the staff to which the telescope is directed in succession, so that $AP = p$ and $PP^1 = s$, both of which are known. Let α be the angle subtended at T by PM, and β the angle subtended by P^1 M, these angles being read. Let $TM = d$ and $PM = h$. Then from the triangles PTM and P′TM



46. SURVEYING BY VERTICAL ANGLES

$P^1M = d \tan \beta$ and $PM = d \tan \alpha$

Therefore $PP^1 = P^1M - PM = d \tan \beta - d \tan \alpha$

Now $PP^1 = s$ $\qquad = d(\tan \beta - \tan \alpha)$.

$$\therefore d = \frac{s}{\tan \beta - \tan \alpha} \quad \ldots \quad \ldots \quad 1$$

Also $PM = h = \quad d \tan \alpha$

$$\therefore h = \frac{s \tan \alpha}{\tan \beta - \tan \alpha} \quad \ldots \quad \ldots \quad 2$$

In the previous formula, $\tan \beta - \tan \alpha$ will be always positive, because the angles taken below the horizontal are called negative angles, which makes $\tan \alpha$ positive when it is larger than $\tan \beta$. The height of the theodolite (q) above the ground must be measured in order to get the level of A with regard to C. The height, p, of the staff above the ground at A must also be allowed for. It must also be remembered that when long sights are taken, the correction for curvature and refraction must be allowed for. The formula for these has already been given.

With work of this kind when the tacheometer is employed the principles are the same, only that with this instrument "stadia" hairs are provided, by which any number of divisions on the staff seen between the hairs represents the distance of the staff from the observing station when the telescope is horizontal.

The measuring angle m I n [47] usually employed has a constant = 0·02, and whatever unit of measurement it is intended to adopt must be proportioned to this on the staff, so that the number of divisions seen between the stadia hairs may represent the distance of the staff from the instrument.

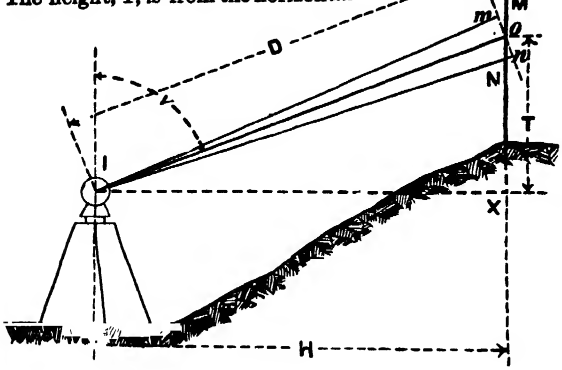
For instance, we shall assume that it is required to read distances in feet. In order to get, for example, ten divisions on the staff to show between the hairs when it is 10 ft. from the instrument, the following will have to be the size of each division when the constant of the measuring angle is 0·02—namely, $10' \times {\cdot}02 = 2{\cdot}4''$ on the staff for ten divisions, or 0·02 foot for each division, or double the size of the division on an ordinary level-staff. If, therefore, the distance from the vertical axis of the instrument to the staff be called D, then, when the telescope is horizontal, $D = g$ the number of divisions between the hairs.

Compensation for Tilting Telescope. When, however, the telescope is tilted, as is generally the case, it is necessary to employ some modification. In the illustration, Io is the central line of vision, and the staff MN is held

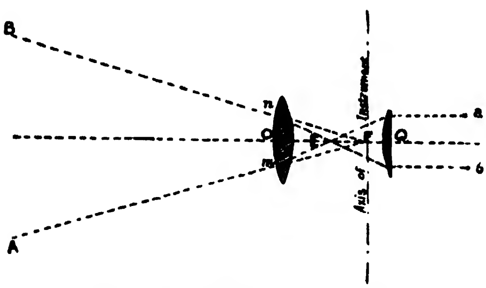
vertical, as shown. If the staff had been held perpendicular to the line of vision, as *mn*, the distance D = *g*, as previously explained, instead of which the hairs cut at MN called G. Then D = G sin V, and the horizontal distance D = G sin² V, and the height from the horizontal to the central line of vision T = H cotan V. When V is more than a right angle, as for angles of depression, the formulæ become

$$H = G \cos^2 (V—90°)$$
$$T = H \tan (V—90°)$$

The height, T, is from the horizontal



47. TACHEOMETRY



48. TACHEOMETER DIAPHRAGM

axis to the central line of vision. This is easily obtained without the use of the formula, as follows. If x and y equal the number of divisions between the bottom of the staff and the two wires, then $\frac{x+y}{2}$ is the number of divisions between the ground and the central line of sight, and if multiplied by the size of one division gives the height in units. For finding the difference of level, three combinations occur, as shown in 49. Calling the height of the instrument *q*, and the difference of level L in the upper figure

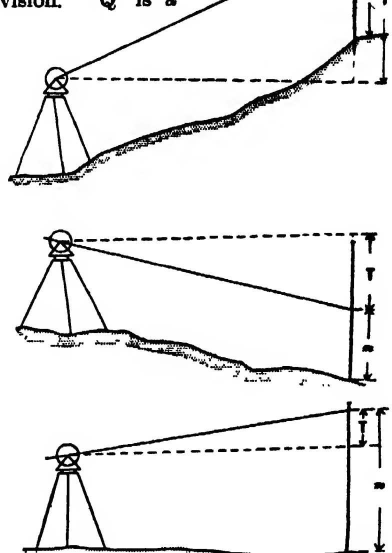
$$L = q + T - m.$$

In the next figure $L = q - T + m$.

In the lower figure $L = q - m - T$.

To ensure the verticality of the staff, the holder should carry a light plumb-line, or have a small circular level fixed to the back of the staff.

Reference has been made to the measuring angle in the tacheometer. The illustration [48] shows two horizontal hairs, *a* and *b*, placed in the diaphragm at equal distances from the central line of vision. Q is a converging lens placed between the object-glass O and the diaphragm. F (the principal inside focus of the object-glass O) coincides with the vertical axis of the instrument. Parallel rays of light pass *a* and *b*, and are deflected to E, the focal point of the lens Q. They leave the lens O in line with its principal interior focus F, forming the measuring angle BFA.



49. LEVELLING BY TACHEOMETRY

Continued

[NOTE]

THE NAVY. On page 163 of the SELF-EDUCATOR appears a paragraph indicating the course o' cadets entering the Navy. These conditions have now been modified, and the last vestige of them disappeared last month (November, 1905). The new regulations are embodied in the following paragraph, and will be dealt with at length in the course which deals fully with the Navy:

Training for Executive and Engineer branches of Royal Navy, and for Royal Marines, is identica until after examination for Sub-lieutenant. Boys must be of European descent, and sons of Britisl subjects. Entrance by examination after nomination. Age 12½—13. Nominations and examina tions three times a year in March, July, and December. Four years in the training establishments costing £100 a year inclusive, is followed by three years at sea, during which a private income o £50 a year is necessary. Then the youth passes examination as Acting Sub-lieutenant, and is sen to England to complete his training, selecting the branch of the service to which he will be attached.

OUTLINES OF EDUCATIONAL TOURS ABROAD

Continued from page 515

The Best Plan of Seeing Historical and Living Belgium in a Short Time
How to Visit France, giving a Model Itinerary and Suggstions for Cyclists

By J. A. HAMMERTON and WILLIAM DURBAN, B.A.

We shall endeavour in the smallest possible space to sketch out model tours in Europe and farther afield, and by giving lists of useful books to read, do all that is within our power to ensure the wisest application of the rules which, derived entirely from our own personal experience, we have already laid down. Bearing always in mind the readers to whom money is a prime consideration no less than time, we have framed our itineraries so that they may be of the greatest use to those who have little leisure and less money at their disposal, taking a fortnight to be the average holiday at the command of our readers, and the financial resources of the ordinary clerk or school-teacher as the measure of expenditure in our calculations.

BELGIUM

Belgium is the most accessible country on the Continent for the English tourist, the cheapest to visit, and one of the most important in any scheme of educational travel. Nowhere are there towns more potent to stir the imagination, to awaken the feeling for romance, than Bruges and Ghent; Brussels is an ideal example of a fine modern capital evolved from an old historic town, while Antwerp is full of bright and cosmopolitan life, and boasts rich treasures of art. For beginners in foreign travel Belgium has the further advantage that it may be visited in one week without undue haste, the distances between the towns being short, and the places of interest near to each other. We therefore make an exception in its case by giving an itinerary for one week.

A Week in Belgium. It is advisable to enter Belgium by way of Ostend, in order to make one's itinerary fit in with the historical interest of the country. Ostend itself is to be ignored entirely, as it is merely a Belgian Blackpool, and the traveller will proceed at once to Bruges, which is only fourteen miles inland.

FIRST DAY. Arriving at BRUGES early in the evening, sleep there, and begin sight-seeing next morning. Go first to the *Grand' Place*, the great open space in the heart of the town, now almost deserted, once the busiest scene in Flanders, if not in all Europe. Bruges in the fifteenth century was at the height of its glory, the most opulent town of Europe outside of Italy, the seat of the Dukes of Burgundy. Its treasures of art and architecture date from that era of splendid prosperity. The *Belfry* is famous all the world over; innumerable poets have written about it, notably Longfellow. Ascend to the top, where the machinery of the wonderful bells is shown, and a fine view of Flanders and Holland obtained. The Belfry was the core of mediæval Bruges, and dates from the thirteenth and fourteenth centuries. Visit the *Palais de Justice*, the *Hôtel de Ville*, and the *Chapel du Saint Sang* (Chapel of the Holy Blood), all close by. Next proceed to the *Hôpital Saint Jean*, which contains some of the rarest gems of Flemish art, the collection of Hans Memling's masterpieces (1fr. admission). The *Academy*, the *Cathedral*, and the churches of *Nôtre Dame* and *St. Jacques*, not to say the many quaint old streets, the canals, and other attractions of the town cannot be seen in one day. Go on in the evening to Ghent, a railway journey of only 25 miles.

SECOND DAY. In the fourteenth century GHENT was the leading manufacturing city of Europe, and as a republic under Jacques van Artevelde it was the ally of England. The town is still a considerable one, and is rich in memorials of its past splendour. The *Cathedral* (which contains the world-famous altar-piece, the Adoration of the Lamb, by Hubert and Jan van Eyck), the *Hotel de Ville*, the *Belfry*, the *Castle* (where the third son of Edward III. was born while Queen Philippa was a guest of the Republic, and was thus known as "John of Gaunt"- - Ghent), may all be seen in one day. These are only a few of the many interesting places in this most interesting town, where one might with advantage spend at least three days. Proceed in the evening to Brussels, 33 miles.

THIRD, FOURTH AND FIFTH DAYS. One has now got a glimpse of the country's illustrious past, and BRUSSELS offers a bright spectacle of its present prosperity. Make first for the *Grand' Place*, in point of architecture perhaps the most curious place in the world. Here are situate the famous *Hotel de Ville*, the *Maison du Roi*, and a number of the ancient *Guild Houses*, the whole square having undergone only slight change in the last four centuries. The *Cathedral* would next be visited, and then one would climb by the *Rue de Ligne* to the high town, where the *Congress Column* is worth ascending for its magnificent view over the town and the fair province of Brabant. The *Park*, the *Royal Palace*, and the *Art Galleries*, with a walk round the *Palais de Justice*, would complete a well-filled day. Next day, by making good use of the splendid tramway service, the outer parts of the town, such as the *Bois de la Cambre*, the Royal suburb of *Laeken*, the *Porte de Hal*, could be visited, and perhaps also the *Wiertz Museum*, which contains the extraordinary paintings of Brussels' mad artist. The third day could be devoted to the little excursion to the *Field of Waterloo*, leaving time for visiting some of the minor places of interest in the city.

SIXTH DAY. One of the most interesting churches in Belgium is the *Cathedral* of MALINES, which few tourists ever visit, because the town is midway between Brussels and Antwerp, and only an occasional traveller seems to think of breaking his journey there, just as there must be a hundred who go straight through from Calais to Paris for every one that gets out to see Amiens. The best plan is to book one's luggage direct on to Antwerp, and stop for two or three hours at Malines before completing the journey to Antwerp, where it would be possible to arrive early in the afternoon. ANTWERP is less rich than any of the other cities in historic buildings, as the town was well nigh destroyed by Spaniards in the sixteenth century, and its prosperity as a great commercial seaport is of comparatively recent date. Its only building of supreme interest is the splendid *Cathedral*. It has a number of minor churches which the tourist with no time to spare need not visit. The best plan would be to go to an hotel on the *Place Vert* on the afternoon of arrival and devote the remainder of the day to visiting the cathedral and wandering about the town. It is one of the most irregular towns

on the Continent, and the tram-lines are the only safe guide for the tourist to follow who does not wish to waste his time in a maze of tortuous streets.

SEVENTH DAY. The *Plantin Museum*, which was the residence and business place of the famous family of printers and publishers who, for upwards of 300 years, carried on a princely business in Antwerp, must take a morning from even the hastiest tourist, and the remainder of the day will be profitably spent in the *Picture Gallery*, with its magnificent collection of paintings by Rubens, Matsys, and the masters of the Flemish School.

Thus in one week, and at very little cost, one can make a beginning in Continental travel, which will whet the appetite for more, and urge the tyro to fare farther afield in the most delightful and most profitable of all forms of education.

Longer Tours. It should be added, of course, that as three days might be devoted to Bruges, the same to Ghent, a week to Brussels, and five days to Antwerp, while Oudenarde is not unworthy of a little excursion, and there is the whole charming region of the Ardennes to explore, one can easily spend from a fortnight to a month in seeing Belgium. But the essentially educative tour is that sketched out above, for which three weeks would allow of leisurely progress, a fortnight for doing it reasonably well, and a week for gaining a good first impression of the country.

Hotels. Hotels in Belgium are cheap and clean. In Brussels one can get accommodation from 5 francs (4s. 2d.) a day upwards. The charge mentioned is contemptibly small for food and lodging, but there are many respectable restaurant-hotels in less central parts where the expense does not exceed that figure. Ixelles is a convenient district for such a lodging. The best plan is to go to one of the better hotels in the town, where prices for bedrooms alone range from 2s. 6d. upwards, and take one's meals wherever convenient. In Bruges, Ghent, and the lesser towns, hotel charges are very modest.

Fares. Our itinerary involves a ticket enabling the tourist to travel to Brussels *viâ* Ostend, Bruges, and Ghent, returning *viâ* Antwerp, Ghent and Bruges to Ostend. There are three trains daily *viâ* Dover and Ostend to Brussels. Fares: Single, 38s. 10d., 28s. 4d.; return (30 days), 70s. 5d., 51s. 8d. Third class is limited to night service. Single, 17s. 6d.; return (14 days), 31s. A small extra payment enables the traveller to return by Antwerp.

The cheapest way is to sail from London and take third-class railway tickets in Belgium. From London to Ostend, vessels of the General Steam Navigation Co. convey passengers twice weekly from St. Katherine's Dock. Fares: Single, 7s. 6d., 6s.; return, 10s. 6d., 9s. Between Antwerp and London, *viâ* Harwich, there is a daily service (Fares: Single, 26s., 15s.; return 40s., 24s.), and two sailings weekly direct by G. S. N. boats; while the Sutcliffe line from Grimsby sails on Mondays, Wednesdays and Saturdays (Fares: Single, 15s.; return, 25s.).

Books to Read. "Cities of Belgium" (3s. 6d. net.), by the late Grant Allen. "Belgian Life in Town and Country," by D. C. Boulger (Newnes, 3s. 6d.). "Belgium and the Belgians," by Cyril Scudamore (Blackwood, 6s.). "Bruges," in the "Mediæval Towns" series, by E. Gilliat-Smith (Dent, 4s. 6d. net). "Bruges la Morte," novel by Georges Rodenbach, English translation, Sonnenschein (6s.).

FRANCE

The richest and most interesting country in all Europe, the most varied, our nearest neighbour—what shall we say of fair France? To mention its many fine provinces, with their wealth of historical and legendary lore, their diversified scenery, their intimate association with England in the days of old, when our Kings were also rulers of this magnificent country, is to sketch out a programme of travel that might well occupy one for many years, and leave the country unexhausted in the end. Picardy, with its dead old towns in the north; Normandy, rich in Gothic architecture and memories of our Norman kings; Brittany, with its natural beauty and its Celtic memorials, its people the kindred of our own friends in Wales, still speaking a language that is practically the same as Welsh; the Loire, with its wonderful castles, "the garden of France"; the Vendée, the Cevennes, Auvergne, Provençe, and all the Roman provinces of the South, boasting, as in the arenas at Nîmes and Arles, the Pont du Gard, and other treasures of classic architecture, gems worthy to rank with the best of Italy and of Greece; the Vosges, unrivalled for mountain scenery, and many more provinces not less interesting in their individual ways—each and all invite us, seeming to say: "Confine your travels to France and you will have enough to do all your days!" That is indeed true, but only the specialist can afford so great a luxury as to familiarise himself with all the glories of this glorious country. We must select from its inexhaustible possibilities of travel just enough to show the reader how he may draw sufficient thence to furnish his mind with a fair conception of its grandeur.

A Fortnight in France. In fourteen days much can be seen, but it is hopeless to attempt a comprehensive tour of France in that time. The great towns of living and historical interest are so far apart that it would be preposterous to endeavour to see many of them in so short a period. Paris, Orleans, Tours, Clermont Ferrand, Nîmes, Lyons, Bordeaux, Marseilles, Nice, Nancy—look at the map of France and you will realise how hopeless it would be to think of visiting these cities, and they are but a few, in the course of a tour that did not extend into many weeks. We must therefore devise a fortnight's itinerary which will give the beginner a good first impression of Northern France, and outline several tours, especially for cyclists, who, above all, can get the best out of the country.

FIRST DAY. By travelling at night, arrive in the morning at ST. MALO. The *Cathedral* is interesting, but the town is more so. Most of the day may be spent to advantage in rambling about the old streets within the ramparts. See the *Tomb of Chateaubriand*

on a little island near the harbour, whither one can walk at low tide. ST. SERVAN and PARAMÉ are close at hand, and may be visited, not for any historical associations, but for their importance as thriving French watering-places.

SECOND DAY. Take train to PONTORSON, stopping by the way at DOL to inspect the fine *Cathedral.* From Pontorson proceed by diligence to MONT ST. MICHEL. This is one of the greatest curiosities in France, and should on no account be omitted. We have spent days there at a time. Stay at one of the excellent hotels on the Mount.

THIRD DAY. If time will permit walk round the Mount, outside the ramparts, to gain a good idea of this most wonderful piece of mediæval architecture. About midday return to Pontorson and train to AVRANCHES, a delightful old town where a large colony of English residents used to exist.

FOURTH DAY. Travel to Bayeux, stopping for an hour at ST. LÔ to lunch and visit the fine *Cathedral.* At BAYEUX, see the beautiful *Cathedral* on the evening of arrival.

FIFTH DAY. Spend a good deal of the forenoon examining the world-famous *Bayeux Tapestry*, reputed to be the work of Queen Matilda (wife of William the Conqueror) and ladies of her Court, recording the story of the Conquest of England. Go on in the afternoon to CAEN, which is deeply interesting to the English visitor as the favourite town of the Conqueror.

SIXTH DAY. Devote to seeing the principal churches—*St. Pierre*, one of the finest examples of Gothic; the *Abbaye aux Dames* and the *Abbaye aux Hommes*, the one erected by Queen Matilda and the other by William, as their penance to Rome for having married within the degrees of consanguinity.

SEVENTH DAY. Leave by early train for FALAISE, the birthplace of the Conqueror. A most picturesque and romantic town, whose *Castle* is well worth visiting. Then in the afternoon proceed to LISIEUX, another historical and picturesque town.

EIGHTH DAY. Train to Paris, breaking the journey for an hour or two at EVREUX to see the beautiful *Cathedral* and to visit a lively, clean, military town of 17,000 inhabitants. Paris will be reached late in the afternoon.

NINTH–TWELFTH DAYS. This is all too short a time to spend in PARIS, but will suffice for a first impression. No town in Europe is of such inexhaustible interest. It may be visited scores of times. We need not outline the sights of Paris, since to do so would occupy too much space and would be of little use to the tourist, who must make up his programme for himself with the aid of a good guide-book. Among the sights, however, one frequently missed is that of the *Cluny Museum*, and this should on no account be omitted by the visitor, no matter how short a stay he may be making. And one afternoon at least should be devoted to VERSAILLES, an easy excursion.

THIRTEENTH AND FOURTEENTH DAYS. Returning home either by HAVRE OR DIEPPE (the former is much the more interesting town) the traveller should break his journey at ROUEN, either for a forenoon or for a whole day. Ourselves, we have stayed for several days in the town and revisited it twice, and advise that at least a day should be given to it if possible, as it possesses numerous fine churches and public buildings, and is of immense historical interest. Rouen was the scene of *Joan of Arc's* imprisonment, mock trial, and burning. *Gustave Flaubert* was its greatest literary son. It is the largest and most important town in our itinerary after Paris, and for that reason alone well worthy of the traveller's study.

Such a tour as we have outlined would give the student a fair impression of historical and living France, but not until he had travelled a good deal in the centre and south could he presume to judge of the wonderful resources of the country, its mighty national life.

Cycling Tours. Normandy is a fine touring ground. Boat to Le Havre, then cycle to Caudebec, Rouen, Pont Audemer (don't sleep here), Lisieux, St. Pierre-sur-Dives, Falaise, Flers, Domfront (most interesting), Mortain, Avranches, Mont St. Michel, Granville, Coutances, St. Lô, Bayeux, Caen, Cabourg, Trouville, Honfleur, Havre. This round can be done easily in the fortnight. In BRITTANY the towns are not so interesting as they are in Normandy, but the country is far more beautiful, and if the roads are not so flat they are less monotonous. Sail from Southampton to St. Malo, arriving there in the morning and setting out the same afternoon for Lamballe, passing by way of Dinan. Thence to S. Brieuc, Étables, Paimpol, Tréguier, Lannion, Morlaix, Landernau, Brest, Telgruc, Plomodierne, Quimper, Concarneau, Pont Aven, Quimperlé, Lorient, Carnac, Locmariaquer, Auray, Vannes, Rennes, St. Malo. This is a circular tour which gives the cyclist, to whom alone it is possible in all its details, a good idea of the towns, villages, and historical sights of Brittany, and may be accomplished in so short a time as eight or ten days.

Routes to France. London to Paris, *viâ* Newhaven and Dieppe: Single, 34s. 7d., 25s. 7d., 18s. 7d.; return (30 days), 58s. 3d., 42s. 3d., 33s. 3d. *Viâ* Dover and Calais, or Folkestone and Boulogne: Single, 60s., 43s. 6d., 26s. 9d.; return (30 days), 89s., 68s. 6d., 42s. *Viâ* Havre and Rouen: Single, 33s., 24s.; return (60 days), 55s., 39s. London to St. Malo: Single, 35s., 25s.; return (60 days), 52s., 40s.

Books and Guide-books. Those who read French are advised to use one of the "Guides Joanne," published at different prices by Hachette and Co., which are by far the best guide-books to the different provinces of France. For readers of English only, Baedeker's "Northern France," price 7s., and "Southern France," price 9s., are recommended. Members of the Touring Club de France can make up their itineraries from an ordinary map, and by sending an outline of their projected tour to the secretary will be supplied, at a very low charge, with sectional maps of the whole route—a most convenient arrangement. Guide-books for Paris are so numerous that we need not specify any, except the late Grant Allen's "Paris" (3s. 6d. net), which is the best of its kind. Richard Whiteing's "The Life of Paris" (Murray, 6s.) is unrivalled as a graphic picture of modern Paris. Read Flaubert's famous novel, "Madame Bovary" before going to Rouen. Read Pierre Loti's "Pecheur d'Islande" before going to Brittany. There are innumerable books of travel in Normandy and Brittany, any one of which cannot fail to be of some value to the intending tourist. "French Life in Town and Country," by the late Hannah Lynch (Newnes, 3s. 6d.), and "Home Life in France," by Miss Betham-Edwards (Methuen, 6s.), are worthy of special mention. A useful little book for those who travel by train or cycle is "The Continong" (Dent, 1s. 6d. net).

Continued

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TEXTILES
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CULTIVATION OF TEXTILE FIBRES

Including Flax, Jute, Manilla, Canadian, and other Hemps. Ramie Fibre—Its History, Nature, Prospects, and Problems

By W. S. MURPHY

Flax. Common flax is the chief source of lint fibres. It is a pretty plant [15]. When the blue flower opens, the fields of flax are clothed in a robe of shimmering azure, tender and delicate in hue. "Blue were her eyes as the fairy flax," sang the sweetest of our great poets. Singularly graceful is the erect stem, about three feet high, branching out at the top, the flowers forming a lovely crown. The long, lancet-like leaves, smooth and glossy, spring from the stems to each side alternately. When the flowers fade, capsules form, and nourish within them seeds, dark brown, glossy, oval, flattened, and sharp-pointed.

Let us examine the fibre. The stem of the flax plant consists of three forms of vegetable substance—the outer bark, the bast or inner skin, and the woody central pith. The bast is the true skin of the plant, and is composed of the fibres from which lint or flax yarns and linen cloth are made.

The History of Flax. The oldest pictures of human industry are those which depict, in the ancient tombs of Egypt, the operations of the flax cultivator. Painted from four to five thousand years ago, these pictures show the agriculturist turning up the soft alluvial soil of the Nile valley, sowing the seed, and pulling up the flax stems when fully grown.

15. FLAX PLANT

Though it probably originated in a subtropical region, the flax plant grows well as far north as Sweden. Up till the middle of the eighteenth century flax was grown extensively in England, specially in Dorsetshire, Lincolnshire, Isle of Ely, and Suffolk. All over Scotland the fibre was grown for local consumption, large quantities being raised in Ayrshire, Lanarkshire, Renfrewshire, Fifeshire, and Forfarshire, where there were linen factories and roperies. In Ireland, where the linen trade had been an established industry for centuries, flax was grown extensively in the Ulster province. But the profitable market for wheat created by the growth of the factory towns in England and Scotland induced the farmers of those countries to reserve their fields for cereals.

At the close of the American War of Independence the British Government, alarmed at the decreasing supply of raw material for an important industry, instituted a premium system for the encouragement of flax cultivation. It is interesting to note that in 1786 Robert Burns, the poet, gained one of these premiums for the excellence of the flax crop raised on his farm at Mossgiel. Premiums cannot arrest economic tendencies. Year by year, decade after decade, the acreage of flax declined, till at the close of the nineteenth century flax culture in England, Scotland, and Wales scarcely covered 1,000 acres. Irish flax culture has had a somewhat different history. With temporary fluctuations, flax production increased in Ulster till 1864, when 300,000 acres were under flax. Since then the acreage devoted to the cultivation of flax has declined, and at present the great linen industry of Ireland depends on foreign countries for ninety per cent. of a raw material quite easily producible in the country.

We derive our supplies of raw flax chiefly from Russia, Belgium, Holland, Germany, and Egypt, the value of the average annual importation being about £3,000,000.

Flax Farming. When cultivating for fibre, it is not advisable to ripen the seeds, because the stems rapidly harden after the flower has faded. The flax farmer therefore buys his seed, and, if he is wise, he pays a good price for plump, heavy, shining seed, of the best brand on the market. The product of poor seed does not repay the labour spent in raising it. Irish farmers have found the seed imported from Riga, the Russian Baltic port, best suited for them.

Having selected our seed, our next care be the soil. This should be a fine dry loam, with a large proportion of silica and lime, alumina and iron in smaller quantity.

An important question comes up at this point. Pliny says of flax, "It has the property of scorching the ground where it is grown, and of deteriorating the quality of the very soil itself." Modern authorities agree with the ancient writer to a certain extent; but it is contended that our artificial manures have done away with that objection. Even without manures, the exhausting effect of flax can be obviated by a simple rotation of crops—as, for example: First year, grass; second, oats; third, potatoes; fourth, wheat; fifth, flax. If an interval of from five to seven years be allowed between the flax cropping of the same land, no injury can result, and the cultivator actually secures one crop without manuring.

Ploughing and Sowing. At the close of harvest, before the frost has taken a grip of the ground, the wheat stubble should be ploughed thoroughly, and the land well drained. In February, plough the soil well up, making a deep furrow. If the soil be light, one ploughing may suffice; but heavy soils require to be ploughed twice in the spring. After the first ploughing has settled, go over the fields again. At the beginning of April, just when the warmth of the sun has strengthened and is causing the weeds to spring, harrow the land to break up lumps and loosen the weeds. Pick out all the weeds as cleanly as possible. Throughout all these operations the level surface of the land should be kept in view, because a regular surface secures uniformity in the length of the plant stems. By giving all plants an equal start in life, you afford them an equal chance in the struggle for light, warmth, and air.

In sowing, follow the same direction as the plough. Having a clean, dry furrow over one inch below the surface, put in a liberal supply of seed, from two to two and a half bushels per statute acre. Fibre plants develop stems most vigorously when thickly sown; the fruit, of course, suffers, but our object is fibre, not seed. The sowing should be followed by a fine seed harrow, covering over with soil. Then draw the harrow up and down again, and crosswise, to make sure the settling of the seed. Smooth all down with a light roller, and leave the rest to Nature for a short time.

Weeding. Weeding is of first importance in flax culture, and calls for the utmost care. As soon as the plants have grown about four or five inches above ground, weeding begins. The weeders must be properly directed and not allowed to work ignorantly. The average labourer thinks that if he takes out enough of the rubbish he is earning his wages; and that is true enough if we are paying only for physical exertion. But flax weeding is not done by mere "strength and ignorance." In the first place, account should be taken of the direction of the wind by the weeders, who should provide themselves, or be provided, with knee mats. For the weeders press down the plants in the course of their work, and if they work with their faces to the wind it gives the plants a chance of regaining an upright position. For the same reason, the pressure on the stems, where unavoidable, should always be straight forward; twisted stems are of no use as flax fibres. Perhaps we have here an explanation of the fact that the best flax culture is carried on by peasant proprietors, assisted by their families and relatives.

Harvesting Flax. Scythe or reaping machine has no part in the harvesting of flax. When the blue flowers fade and fall, and the rough balls, or capsules, are formed, the reapers go into the field and pull the plants up by the roots, laying out the stems so that the long and the short may be readily separated. Before pulling, it should be ascertained that the seeds have just changed from the pale green of their infancy to the light brown that shows they are beginning to ripen. Another indication of the readiness of the stem for pulling is the yellowing of the stalk. The seeds should not be allowed to ripen, unless the object of cultivation be seed production.

A large amount of flax is grown for seed—in India especially—and the industry is highly important, supplying us with linseed, linseed meal, linseed oil, oil-cake for cattle-feeding, and other commodities; but as our object is fibre production, we shall not study these products of the flax plant at length.

Various Kinds of Hemp. The true hemp plant stands almost alone in the vegetable world; the other members of its family have gone out of existence. It has no other name. Even the botanists, when they say *Cannabis sativa*, are merely saying "Hemp cultivated." All nations call it by the same name, the difference in sound being only lingual, and explainable by philology. But the plant has given its name to fibre which has been derived from a large number of plants nowise related. This fact should be carefully noted.

On the face of it, nothing seems more natural than that Manilla hemp should be derived from the hemp plant growing in Manilla and cognate regions. The fact is quite contrary. Manilla hemp is a fibre derived from a kind of palm, related to the plantain and banana, and has been called "hemp" because it resembles in quality and use the fibre derived from the hemp plant. Similarly, we have *Canadian hemp*, *Bowstring hemp*, *Sunn hemp*, and *Deckannee hemp*, all different classes of plants, and yet alike in yielding a fibre which may be regarded as hemp for all practical purposes. We do not justify the nomenclature—we merely explain it.

Hemp. *Widely distributed over the globe, hemp, properly so-called, varies greatly according to climate, soil, and manner of cultivation. An annual—and probably a native of Southern Asia—it has become naturalised in all parts of the world, because the vitality of the plant is such that severity or uncongeniality of climate dwarfs but does not kill it.* The chief climatic enemy of hemp is frost, and it comes to full perfection only in those countries where the summer is long enough to last out its life—a period of nearly five months. Hemp does not favour extremes; it should be the chosen garment of philosophers. With a mild and moist climate, the plant grows to a height of twenty feet; to the torrid sun of the southern tropics and to the cold winds of the north, equally, it yields a stem of about three feet. Erect in stem, the leaves branching off in spreading groups of four or five long serrated fronds, a crop of hemp in bloom presents the appearance of being the close intermixture of two different plants. Male and female stems grow up together, the flowers of the male being clusters of small yellowish green blossoms, while those of the female form into crowded spikes, with tufts of slender fibres coming out of the capsules.

16. SEEDLING OF ABACA
The plant producing Manilla fibre

Hollow, or filled with a soft pith, the stem of the hemp plant consists of a woody material covered with a fibrous bark, the former being what is called the *reed*, or *boon*, and the latter the fibre, or *hemp*.

The plant gives off numerous seeds, large quantities of which are used for the feeding of tame birds, such as canaries. When pressed, the seeds yield an oil used in some countries as an illuminant; but chiefly known in commerce as a paint medium and material for mixing with resinous gums in the making of varnish. *Hashish*, or *bhang*, a narcotic, indulgence in which has been a vice among the Hindus for many generations, is made from the flowers and tender shoots of the hemp plant.

17. JUTE FIBRE

British supplies of hemp are chiefly derived from Southern Russia, Poland, France, and Germany. Though cultivated to some extent in the fenlands of England, and in some parts of Ireland, early in the nineteenth century, hemp has now practically ceased to be counted among British crops. The reasons for this are not far to seek. Hemp requires a rich soil and plenty of moisture; British farmers find it more profitable to devote their best soils to other crops. The argument, however, does not apply with the same force to many of our Colonies, in which conditions ideal for hemp cultivation prevail.

The first aim of the hemp cultivator is to get a long and vigorous stem before flowering begins. After flowering, the stem hardens and tends to irregularity. Hemp cultivation follows the same process as that of flax, but with less labour and attention, the plant being a noted weed-killer.

Canadian Hemp. Indigenous to North America, allied to the periwinkle and the oleander, this plant yields a very strong fibre. Long before the white man had invaded his native home, the Red Indian used this fibre for making fishing-nets, matting, and wove it into a rough canvas cloth. The plant is easily raised, and attains the height of five feet. Reliable and strong, the fibre is worthy of the attention of Canadian cultivators, and of British canvas manufacturers and rope-spinners.

Bowstring, or Rajmahal Hemp. One of the strongest and finest of Indian fibres, this plant grows on barren, sandy soils. The only difficulty in the way of general cultivation and diffusion of the Bowstring hemp plant over tropical lands, otherwise barren and useless, is its climbing habit. In other respects cultivation is easy. For many centuries the primitive native tribes have used the fibre for bowstrings, and its strength and elasticity are very remarkable. Owing to the absence of industrial demand, the fibre is chiefly consumed in the localities where it grows wild. The natives cut the leaf-stems in two lengths, which they split and dry. Then the pieces are softened in water for about an hour, the fibre being scraped off with a rough stick. Fibres prepared in that primitive way have been tested with hemp, and showed a tensile strength 150 per cent. greater.

Sunn Hemp. Closely allied to the common furze of the home moorlands, *Crotolaria juncea*, *Sunn hemp*, *Indian hemp*, or *Jubbulpore hemp*, as the plant has been variously named, grows several feet high, with slender, rigid branches. It is to be found in the Malay States, Australia, and all over the Indian Empire, but the western and southern provinces of India produce the best qualities of fibre. The plant needs a soil well drained, but of comparatively poor quality; rich soils tend to make the fibre harsh and coarse. At present the fibre is little known, because no regular supply has ever been assured to the market. We believe that, if a supply could be relied on, manufacturers would adopt it for many purposes. Large tracts of Northern Australia, seemingly useless, would produce splendid and profitable crops of Sunn hemp. The yield of poor land averages over 600 lb. per acre.

Deckannee Hemp. Of the mallow family, the *Ambari* or *Deckannee* hemp plant is cultivated in Ghutia Nagpur, the Central Provinces, Madras, and Bombay. The fibre is chiefly used by the natives for making twine, ropes, and sacking. When properly prepared, it is white, soft, and silky, and is held by many to be a possible rival to jute. The plant adapts itself readily to any soil, and it grows as far north as the shores of the Caspian Sea. Experts are strongly of opinion that the growing of this plant, requiring little or no capital, would be of immense service to poor cultivators unable to produce either jute or cotton.

Manilla Hemp. Canvas manufacturers and rope-spinners agree that Manilla hemp is the most valuable raw material they at present possess, and the market faithfully reflects their opinion. It is the highest priced of all the larger vegetable fibres. We have already indicated the character of the plant and its place in the vegetable kingdom. According to high authority, the Philippine Islands have been deputed by Nature to supply this fibre to the rest of the world.

Says Dr. Morris : " The Manilla hemp industry of the Philippines is fostered by very exceptional circumstances. The plant [16] is a native of the country. It is cultivated on virgin soil, of which there is, in that part of the world, a considerable extent, and, in addition, the labour supply is cheap and abundant. It is important to bear these facts in mind in starting the cultivation of any fibre that is likely to come into competition with Manilla hemp. Even in the Philippines, there are districts in the western and northern parts, with a drier climate, where the plants will not grow. Hence, it is useless to attempt to establish a Manilla hemp industry in any country where the soil is not rich and where there is not an abundant rainfall well distributed throughout the year."

Even with this caution, coming from a high authority, we cannot agree that the Philippines must be left in sole possession of the Manilla hemp supply. There are regions in the British Empire having all the requisites described as necessary. When we consider that the total cost of establishing a plantation is not more than from £5 to £8 an acre, and the annual charge for efficient maintenance little more than 30s. per acre, the enterprise seems far from prohibitive in its risks. Within two or three years the cultivator reaps a crop of from 500 lb. to 700 lb. per acre of cleaned fibre. Taking the average price of Manilla hemp, this means a return of about £12 per acre. The plant grows to a height of about 12 to 20 feet, and requires very little attention or cultivation of any kind.

Jute. Jute fibre [17] is derived from a plant which botanists name *Corchorus Capsularius*, grown extensively in India and China. Under fair conditions the plant grows to a height of 20 feet, yielding a fibre of great length and uniform quality. The fibre comes from the inner bark of the long stem, and so readily separates into a soft, silky tress of fine hairs that the original users of it inquired no further into its qualities, but for centuries utilised it in that form. Both Hindus and Chinese made coarse sacking and gunny bags of jute long before Europeans came to trade with them, and when the Westerns began to offer goods for goods those natives packed nuts, oil-seeds, and other produce into the gunny bags for shipment. This practice had been going on for over 200 years with British traders before it occurred to anyone to inquire into the nature of the fibre of which those bags were made.

An East India Company official, whose name is lost, conceived the idea of investigating the matter, and, having discovered the gigantic fibre, procured some samples and sent them, with all the enthusiasm of a discoverer, to London, Hamburg, and America. This was towards the close of the eighteenth century; but at that time every manufacturer was more or less absorbed in " conquering " cotton, or in watching its victorious course, and the jute fibre was forgotten. Some portion of the material had been sent to Abingdon, Berkshire, and after lying neglected for about ten years, or perhaps more, the fibre was taken out and tested. The results seemed encouraging at first, and because the fibre had a softness resembling wool, it was made into carpets. This was a blunder, and led to failure and disappointment. No effort is ever lost, however. The fact that jute had been introduced became a part of the history of the textile trade, and attention was bound to revert to it sooner or later.

Development of Jute. Indirectly, cotton, the superior rival of jute, was the cause of rousing renewed interest in jute. In 1828 a merchant in Dundee, named Watt, finding the demand for cotton bagging larger than the supply, imported 364 cwt. of gunny bags direct from India. Others followed his example and a trade in gunny bags arose.

Mr. Watt began a series of experiments with jute. The extreme length of the fibre rendered it unsuitable for British methods of spinning; but Mr. Watt devised a breaker-card, which reduced the fibre to workable length. By the

year 1832 most of the difficulties had been overcome, and jute manufacture became an accepted branch of the textile trade. Not for another 30 years, however, did jute attain its rightful place among textile fibres. At last it occurred to a Dundee manufacturer to inquire closely into the nature of the fibre, and he discovered that it was divisible into still finer fibres, and placed jute in the category of true textile materials. Formerly relegated to canvas-weaving, plaiting, rope-spinning, or other operations requiring a mere length of continuous thread, jute is now chiefly used in weaving cloths such as sackings, Hessians, baggings, and similar fabrics.

Ramie. In the year 1849 the attention of British textile manufacturers was called to sample handkerchiefs woven of a material then utterly unknown in the Western world. Inquiry brought out the fact that this material was the fibre of the plant [18] variously named *Ramie*, *China Grass*, *Chinese Nettle*, and *Rhea*, and described by botanists as a shrubby nettle, indigenous to India, and grown in China, Japan, and the Indian Archipelago. A patent was taken out for the preparation and manufacture of the fibre, and at the great Exhibition of 1851 three prize medals were awarded for ramie, or China grass fibre, as it was then called, demonstrating that, properly prepared, ramie fabrics could be made equal in every quality to the finest French cambrics.

18. RAMIE PLANT

Stimulated by the interest aroused, the authorities at the Royal Gardens, Kew, sent living plants to the principal Colonies, the climate of which appeared suitable for their cultivation. For about 14 years nothing more was heard of the fibre, but in 1865 the American Consul at Bradford brought it to the notice of his Government, advising the culture of the plant, wherever possible, for textile use in America and export to Great Britain. Responding to the suggested rivalry, the Kew authorities once again sent out specimens to the botanical gardens of all the principal Colonies, but neither from the United States nor the British Empire was any result visible. Some impression had been created, however, for in 1869 the Indian Government offered two prizes of £5,000 and £2,000 to the inventor of a machine which would prepare and clean the fibre for the European market. The sole competitor for these prizes was a Mr. Greig, but his machine was adjudged to have failed in meeting the conditions, and no award was given.

Difficulties of Preparation. The parties to this abortive competition have been blamed, but the quarrel is of little interest to the textile manufacturer. One fact, however, was brought out—the problem to be solved in the preparation of ramie is not single but two-fold. First, the fibre has to be taken from the stems; secondly, it must be freed from the natural gum inherent in all plants of the nettle variety.

For a few more years the fibre went out of public notice, but the Paris Exhibition of 1887 brought out several machines invented for the preparation of ramie fibre. These machines professed to offer solutions of the decortication problem—that is, the separation of the fibre-containing bark from the stems. Solution of that problem involves a great deal more than the success of ramie, and the trials were, therefore, watched with intense interest. None of the machines satisfied the judges, and, of course, disappointment was great. Again, in 1891, trials were held in Paris, but with no better results. For the moment these failures seemed to place ramie in the category of fibres which are incapable of being utilised under industrial conditions, and are more numerous than most people are aware.

During the later years of the 19th century the fibre was being seriously considered in Germany, France, and the United States, and employed in several minor industries, such as the manufacture of incandescent mantles, paper for banknotes, and other specialities. Within a short time, ramie had been given an

increasingly important place among textile fibres by both French and Germans.

Difficulties of Ramie. Never wholly relinquished, the subject was again brought prominently before the textile fibre-users of this country by Mr. Edwards-Radclyffe, of Staines, and from the practical interest aroused it would seem that this new fibre has come to stay, and act an important part in textile industry. When considering any new fibres offered, we must keep closely to practical fact. The Chinese and Hindus have known and used ramie fibre for hundreds of years; but those highly ingenious races have continued to prefer silk and cotton, though both require more costly methods of cultivation.

Ramie, *Bœhmeria nivea* **[18]**, is a shrubby nettle, and one of the preliminary difficulties in dealing with it arises from this fact. The stalk is knotty, and secretes a peculiar gum. Our fibre is the inner bark, growing under a thin, brown outer bark. It will readily be understood that the stripping of such a bark by mechanical means presents problems of no ordinary difficulty, and the failures described will be understood.

Decortication. Let us see, however, the way in which the stripping has actually been done. When the stem has been cut, the Chinese cultivator peels off the bark by hand while the bark is yet soft and green, separating the fibre in a very efficient manner. The ribbon of bark is drawn through a hard substance held between the finger and thumb, the operation clearing off the outer bark and a portion of the gummy substance. Another method is to draw the strip of bark over a fixed bar of wood or iron, with a rubbing motion. Then the fibre is flung into water, rinsed a little, and hung up to dry. In this condition the fibre is supplied to manufacturers. Having been imperfectly cleared of gum, and the gum having hardened, degumming is very difficult, though not insuperably so. If, as Mr. Edwards-Radclyffe advises, the whole process of decortication and degumming, or filassing, were carried through while the fibre is soft, the process would be much easier, and planters would present to the textile market a fibre irresistibly attractive—white, lustrous, soft, fine, and of great tensile strength.

Cultivation of Ramie. Though a tropical plant, ramie will grow in England and Ireland. We do not contend, however, that its cultivation should be undertaken in the British Isles. The enterprise offers scope for the energy and ability of British Colonists in every region of the Empire, and an opportunity of making large profits while serving efficiently the industrial interests of the nation.

Let us begin with the seed. Plants can be readily transported, and they take root quickly; but it is better to start at the beginning when possible. Fill a few shallow boxes, about 3 inches deep, with good mould, and sprinkle the seed very sparsely over the surface, then cover with finely sifted earth. Dip the boxes in water occasionally, to let the liquid sap through the mould, and spray regularly. When the seedlings begin to appear, keep them in a shady corner out of the direct rays of the sun. As soon as the roots have formed and the little plants begin to stand up, thin them out, leaving each plant about 3 inches of space, and plant the thinnings in similar boxes. Carefully shading and watering them till they are about 3 inches or more high, gradually harden them to weather conditions, and then plant out in a well-manured and deeply tilled nursery patch, allowing each plant 4 feet of space, to encourage lateral shoots. As the shoots branch out, splice and peg them down into the earth, so that they will take root. When rooted, remove them into another nursery, or plant them out. In this way a large plantation can be made out of a few seeds.

Plantation. Having got our plants, our next care is the plantation. As a matter of course, different climates require different methods; but a few general directions will apply to all climates. Plough deeply and manure the fields well. The plant will grow in poor soil, but the richer the soil the better the crop. Few plants are so responsive to good treatment. Set in blocks of two or three rows; leave between each block space large enough for a trolley or a plough to pass. Pay close attention to weeding, hoe well up to the roots; snip off all low lateral shoots as they appear, to encourage length and straightness of stem. The longer and straighter the stem the better the fibre.

The plantation, once started, lasts from 16 to 18 years, yielding regular crops all the time. The reaping is done by hand, the stems being cut off at the root. Now we gain the benefit of the space between the blocks; the trolley passes from block to block of the plantation, collecting the cut stems, and bringing them to the decorticator.

Claims for Ramie. As yet ramie culture is in its infancy, and there are many details in the work which can be determined only by long practical experience. China is the only country where ramie has been cultivated to any extent, and there it takes the form of a kind of cottage culture, affording us little light on the problems involved in extensive plantations.

The merits claimed for ramie have not been put to the infallible test of the industrial market, but they are worthy of record as an encouragement to inquiry and study:

1. Ramie is many times stronger than cotton, flax, hemp, and similar fibres.
2. It has a long staple, from 3 in. to 9 in.
3. It is easily grown, as it acclimatises itself almost in any zone where agriculture is possible, with varying results, giving in some latitudes as many as four crops per annum.
4. It is beautifully lustrous, resembling silk more than any other fibre.
5. It does not rot.
6. It is non-elastic, and therefore invaluable for machine belting, ropes, and measuring tapes.
7. There is nothing produced in wool, cotton, flax, hemp, or even silk, which ramie cannot imitate and in most cases excel.

Continued

COMPOSITION AND COLOUR

The Value of Composition. How to Suggest Emotion in Art. The Importance of Originality. A General Colour Scheme

Continued from page 600

By P. G. KONODY and HALDANE MACFALL

THE student will next find his drawing not only of importance in its accuracy as to form, but he will begin to realise of what immense importance it is *where in the picture he puts that drawing.* He has, in fact, realised that arrangement, or composition, is of enormous value in creating the impression he wishes to create. This will thrust its importance upon the student very early. For when his training in drawing has made him master of the great secret, he has to remember that he has only learnt that which is to enable him to build up his picture or impression.

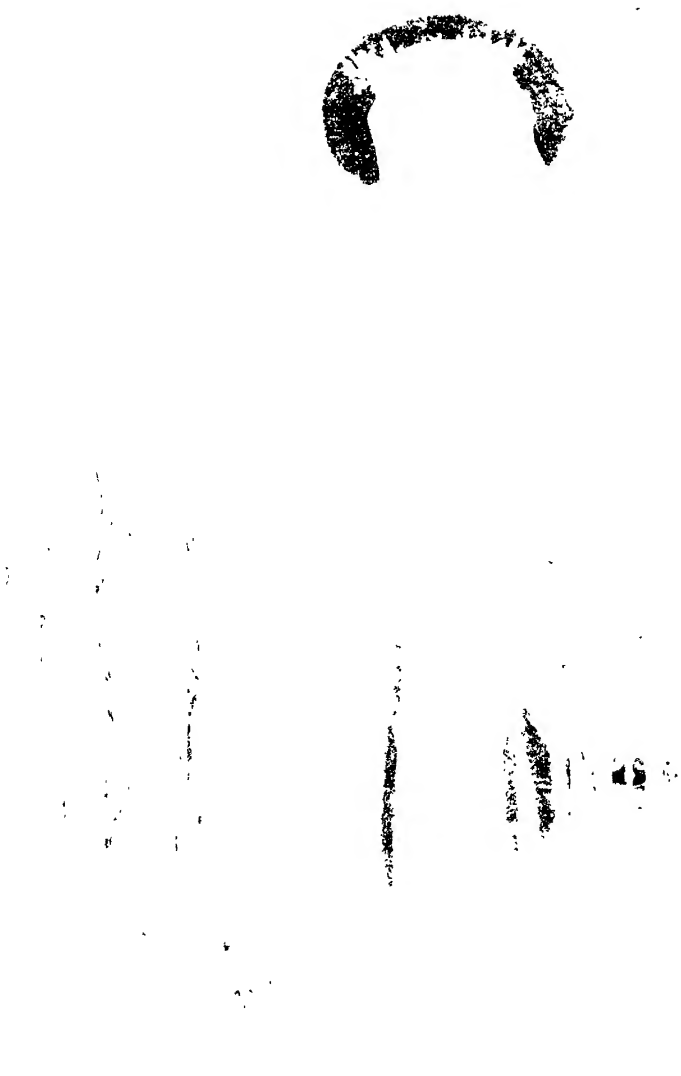
Let us take, for example, Holman Hunt's "Lady of Shalott" and Sargent's "Ellen Terry as Lady Macbeth." We shall find in both these well-known pictures, that the head of the figure being near the top of the design, a strange dignity ensues as regards the relation of that figure to the rest of the picture, as compared to the effect it would produce if placed low down. We shall also find that the effect of dignity is sti'l further increased by the height of the figure, and the fact that its main lines are vertical. The student has, indeed, had thrust upon him the beginning of the laws of composition, of which he will be a student to t e end of his days. Let us take first the single figure of "Ellen Terry as Lady Macbeth," by John Sargent. Here we find the act of usurpation, the crowning of the murderous queen by herself, set down in the composition with rare art. The crown in the upraised hand draws the eye to the agonised face, while the tall figure is draped in long upright lines of darker hue which lift the figure to tragic intensity, without one crossing horizontal line to check the tragic dignity of the face. The sheer drawing of this picture is a masterpiece. Again, in Holman Hunt's little black-and-white drawing of "The Lady of Shalott," in Moxon's Tennyson, we have the beautiful head of the lady almost pressed down by the top of the picture, giving to the figure the sense of the burden of the awful tragedy that has fallen upon her.

ELLEN TERRY AS LADY MACBETH,
BY J. S. SARGENT

A remarkable instance of majestic dignity expressed by compositional lines

Now this relation of the figure to the rest of the picture is enormous in its value in creating the impression, but an even more powerful factor in the building-up of the impression is the arrangement of the dark and the light masses in their effect upon each other and their relation to the whole. It is best to show this by example; but let the student first realise the close relation of all the arts and the sameness of their laws. He will benefit greatly by the lessons that every art has to teach him.

Painting is closely akin to music, and just as the line for drawing the forms yields the dominant effect of his composition—what may popularly be called the tune, so the arrangement of the light and dark masses of colour yields him his harmonies; just as in an orchestra the deep violoncellos and wood and brass build up the accompaniment and increase the impression. And just exactly as in music we may make the orchestra yield us the thunder and roar of the



THE LIGHT OF THE WORLD

From the Picture by W. Holman Hunt

A noteworthy example of symbolis
charged with

"LAS HILANDERAS" (THE SPINNERS), BY VELASQUEZ
One of the great Spanish master's finest works

angry heavens, the tramp of armed men, the clash and fury of contending passions, the laughter of lightest merriment, the gay trip of dancing feet the subtle tenderness of the twilight or the sigh of a woman; so with colour, according to our mastery of its mighty powers, may we yield to the eye all the impressions of life that may be emotionally seen and felt through the sight, from the crash of the mightiest tragedies that fall on man to the uttermost delicacy of tendernesses that haunt the vision of a child.

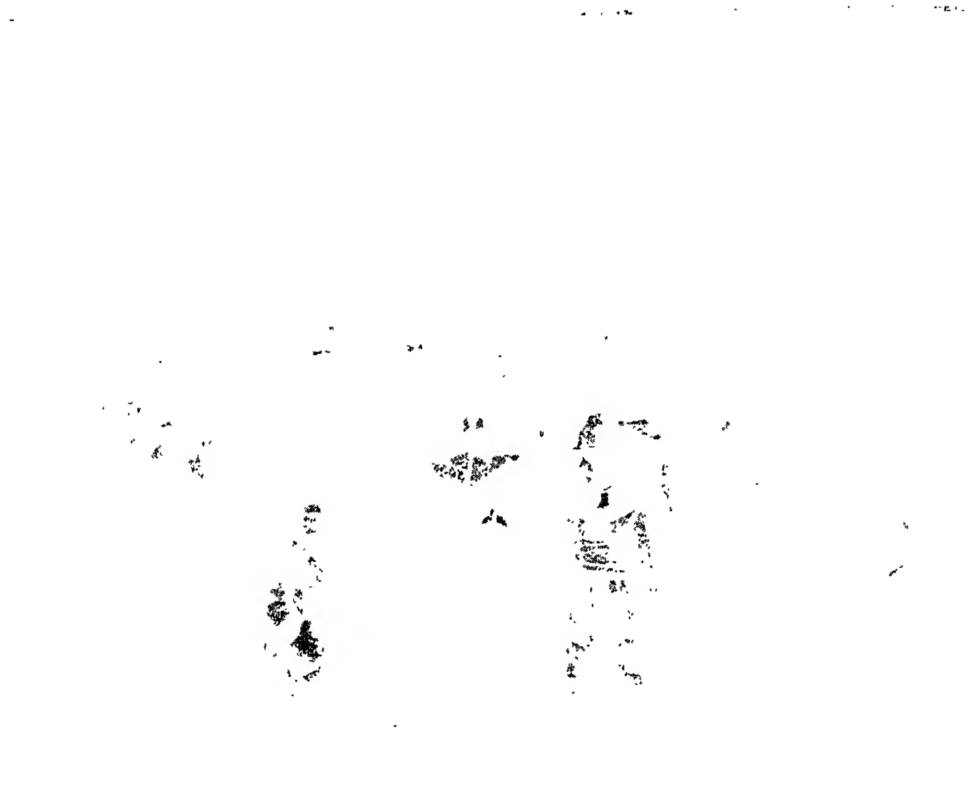
The Portrayal of Emotion. There is no emotion felt by the human being through his sense of sight which may not be rendered in colour by the mastery of the art of painting. And line and form and composition all play their equal part in building up that framework on which is to be placed the right and proper colour that gives the thrill of emotion through the eyesight, and so sends it in waves of colour into our senses, rousing, without our being able to tell why, the effect that the artist desires.

But, the student will ask, how is he to learn composition? Here again, as in drawing and colour, he must teach himself. And the only way to learn arrangement is to train the eye first through the work of the masters. By far the best and simplest way, as it is also the most delightful, is to make collections of black-and-white reproductions of pictures from every source within his reach—magazines, papers, books, photographs. The eye, thus constantly trained to good work, becomes so alert, and acquires such rightness of vision, that no amount of lecturing and theory can equal—nay, can approach. Let him begin with the pictures that are his favourites, and he will soon find his hand's skill trying to rival that of the masters. Let him from the beginning not copy the compositions of the masters, but try to evolve arrangement like theirs to express his own ideas; for he will early find that *their* arrangement makes his own brain fertile and feverishly anxious to express rival ideas, and to alter and rearrange and recast *their* ideas. From the very beginning let the student try to *create*—no matter what bad falls he may get in his endeavours.

Originality. If possible he should haunt picture-galleries and sale-rooms, and try to get any effect that has appealed to him. He will thus keep himself from being the mere imitator of one man, and will gradually evolve a style of his own, and a wide range of handling to produce results in a manner fitting to his own emotion. He will also train his colour-memory, and his copying will not be servile imitation.

There are to-day many monographs written upon the works of painters, which give a large number of reproductions of their works that are helpful in training the eye of the student.

What the artist can do with arrangement can partly be realised when we see what can be



"THE MUSTERING OF CAPTAIN COCQ'S COMPANY," CALLED "THE NIGHT WATCH," BY REMBRANDT
Illustrating "the broad, deep, resounding backgrounds of Rembrandt"

done with so rigid and hard a medium as the pen-line. Apparently the simplest of drawing effects, the pen-line is perhaps the most difficult of all. It is marvellous to see the variety in the style of artists in this medium alone. And when it comes to the use of the paint-brush, the student can in some measure grasp the fact that it will yield him a wide range of style, from the broad, deep, resounding backgrounds of Rembrandt and Velasquez (as in the examples which we reproduce) to the daintiest light brávurá effects of such painters as Le Sidaner. And the student would do well to learn all that every master can teach him. Above all, let him face the vastly encouraging truth that each generation needs its own artists—that the artist, above all things, appeals to his own age. The old masters are our great teachers, our helpers ; but for the generation in which we live we need our own poets, our own seers, our own artists.

Great Art deals with Contemporary Life. It is scarcely too much to say that all truly great art—except where it is purely decorative—deals with contemporary life, with things not invented by the artist, but actually observed by him. The old masters who devoted themselves to scriptural subjects form no exception to this rule. The subject was often merely an excuse for painting contemporary portraits in the costume of the time, or scenes that presented themselves to the painter's eye. The decline in the art of the early nineteenth century was mainly due to a departure from this rule. The learned reconstructions of the past which were then in vogue amongst academic painters are, however, rapidly falling into oblivion ; they have no real vitality. It was left to the modern French, the Barbizon men and the Impressionists, to return to the right path—to the study of Nature and contemporary life. Their efforts indicate the right direction, though their methods cannot always be recommended to the student.

Amongst the collections of studies in composition by great artists, perhaps one of the most valuable to the student is Turner's "Liber Studiorum" ; and though the originals are beyond the purse of many students, there has been published of late a capital book of reproductions in a cheap process at the price of half-a-guinea.

Detail of Secondary Importance. In making his studies for the composition of his pictures the student should not weight his hand with detail, but should use a stick of charcoal, or a water-colour brush, and sweep in broadly the masses of light and dark where he

A FRESCO, BY BENOZZO GOZZOLI, IN THE CAMPO SANTO OF PISA

Though it is meant to represent a scene from the Old Testament, it is really an exact representation of the Vintage in Tuscany

would like them to come in his colour scheme, only quite vaguely suggesting the forms that he will afterwards develop in detail. He will thus not only save himself an enormous amount of trouble, but he will be surprised to find how his mastery in composition grows by leaps and bounds. And he will start upon his picture with a good general idea of the finished effect.

It is a good thing also to get a rough effect in colours from this black-and-white scheme, as a guide for future use. These exercises in composition have an added advantage in training the hand to free, bold brushing, and will lead the student by many splendid accidents to the discovery of masterly handling which he will soon strive to get deliberately and by skill into his style. He will find Poore's "Pictorial Composition" (Macmillan) a valuable help.

Colour. Although the use of colour is primarily a matter of observation, feeling or instinct, it can only benefit the student to have an elementary knowledge of the nature and symbolism of colours. Without going into the purely scientific questions of the causes which produce the sensation of colour, and without analysing the spectrum, it is necessary to know that theoretically white is a mixture of the three primary colours—yellow, red, and blue. If the actual mixing of these paints produces a result far removed from white, this is entirely due to the impurity of the pigments. A mixture of two of these colours forms a complement to the third, thus:

Green (blue and yellow) is the complementary colour to red.

Violet (blue and red) is the complementary colour to yellow.

Orange (yellow and red) is the complementary colour to blue.

The juxtaposition of complementary colours produces a pleasurable sensasation to the eye.

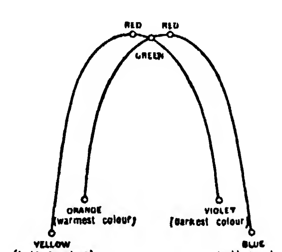
Black and white are not colours strictly speaking; that is to say, they are not contained in the spectrum, but are surrogates for pure light and pure darkness. In considering the scale of colours we must distinguish between the scale from light to darkness and the scale from warmth to coldness. Yellow, which, according to Goethe, is sunlight dimmed by the atmosphere of the earth, is the lightest colour. Though blue, if we follow the same authority, is darkness cleared up by the same cause, it is not the opposite pole to yellow. The scale from light to darkness leads from yellow to its complementary colour, violet, whilst the scale from warmth to coldness leads from orange (the warmest) to the complementary blue (the coldest).

In a diagram this can be expressed by two curves, terminating in these four colours, with red and green, which are more or less neutral in both scales near the apex of the curves.

The symbolism of colour is by no means an arbitrary convention, but is strictly based on the innate quality of the different colours which, according to their varying degrees of lightness and warmth, directly affect our senses and our imagination. Thus

a. Lightness corresponds with gaiety.

b. Darkness corresponds with seriousness.



c. Warmth corresponds with emotion, and

d. Coldness with absence of emotion.

Orange, which combines gaiety and warmth, is the opposite pole to blue, which combines seriousness and

coldness; yellow (gaiety and coldness) to violet (seriousness and warmth).

Black and white are only opposed as regards lightness, not as regards warmth, both being cold. They are the representatives of organic lifelessness, and they, as well as their mixture—grey—are therefore indicative of mourning. Through their contrast between light and dark they partake of *a* and *b* but not of *c* and *d*. Mixed with other colours they make these colours colder; but the mixture with white has a gayer, that with black a more sombre, character than the pure colour. Black is the colour of the sombre sphere of shade; white, of the glorious sphere of light.

Yellow and Violet. Yellow is the nearest approach to pure light, or white; violet to pure darkness, or black. As colours, therefore, they represent the extreme contrast between gaiety and seriousness. Yellow signifies the greatest vitality in the spiritual sense; violet the deepest renunciation, resignation and melancholy. Of all colours, yellow is the most easily soiled, and immediately loses its ideal character, producing the opposite effect. It is therefore the symbol of shame and humiliation. Impure yellow is to be found in the jaundiced complexion of an ailing person; it is the symbol of envy, malice, and hatred.

Violet expresses generally melancholy, resignation, and sombre seriousness, but signifies, through the participation of the emotional red, a seriousness which is the result of sad experience, that has not entirely overcome the recollection of lost pleasures, and therefore savours of melancholy regret.

Orange and Blue. Orange, the warmest colour, is influenced by the participation of yellow, and therefore retains to a certain extent an ideal character, which is not allowed to achieve its full effect by the sensual glow of red, the most emotional and most effective colour. It expresses pathos and dignity, and is the symbol of great splendour and majesty.

Blue, the coldest colour, expresses calmness and absence of emotion but contains sufficient colour to prevent it from sinking to the funereal stillness of black. As an ethical symbol it is not quite neutral. It signifies modesty, faithfulness, gentleness, and a certain longing without the acerbity of a melancholy resignation, which is sounded by violet.

Red and Green. Being midway in the two scales of intensity, these are, so to speak, the rulers of the entire sphere of colour—the principal colours. Red, the king of colours, being a primary colour, naturally stands higher than the secondary green, the queen of colours. Green excels in beauty and nobility the two colours which are of equal rank, orange and violet—as red excels the equivalent primary colours, yellow and blue, as regards nobility, power, and beauty.

Red expresses the height of emotion and is the symbol of passion, rage, warlike courage, and sexual love.

Green, as the complementary colour to red, symbolises kindness and gentleness, and is as soothing to the eye as the fiery red is exciting. Compared with red, green has a certain lack of emotional effect, but the yellow, which is one of its constituents, prevents it from sinking to the indifference of blue, and rather raises the impression to one of serene freshness and joy of life.

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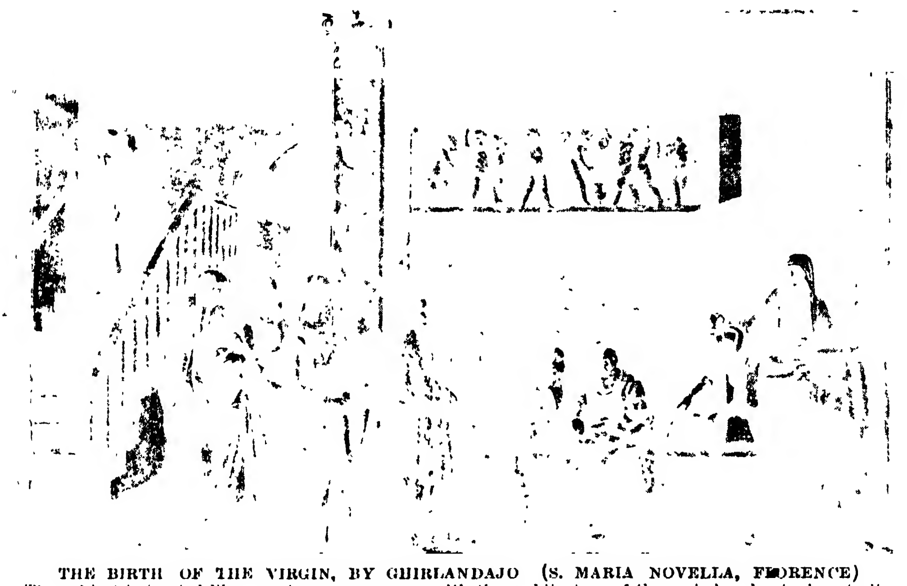


THE BIRTH OF THE VIRGIN, BY GHIRLANDAJO (S. MARIA NOVELLA, FLORENCE)
The subject is treated like a contemporary scene, with the architecture of the period and actual portraits

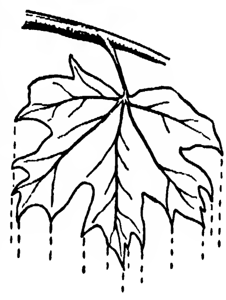
FLOWERS AND THEIR FRIENDS

Flowers and their Sources of Life. Water, Wind, and Animals in Their Relation to Flowers. How the Insects Help

Continued from page 508

By Professor J. R. AINSWORTH DAVIS

Guarding the Health of Plants. The health of a plant is prejudiced if water accumulates upon its leaves, and we accordingly find various contrivances to prevent this. A very pretty device is found in the " dripping points " into which the leaves of many trees are drawn out, and which may be seen in the lime (*Tilia*) and Norway maple (*Acer platanoides*). Rain drops from these points as from the tips of the ribs of an umbrella [91]. The arrangement is very characteristic for the trees of forests growing in wet latitudes, especially the tropics. An interesting illustration of its utility is afforded by attempts which have been made to introduce into Java and the Cameroons trees of economic value from drier climates. The leaves of these plants being unprovided with dripping points, rain is collected upon them and led to the growth of moulds, which soon put an end to the experiments.



91. NORWAY MAPLE

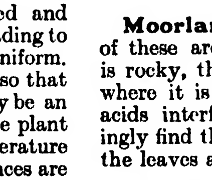
Another method by which leaves get rid of unnecessary moisture is by the development of a velvety surface, which greatly increases the area from which it can evaporate.

Since *Xerophytes*—desert or drought plants—have to make the most of the water available, we find that adaptation to this end is brought about in a variety of ways. Absorption is promoted and transpiration checked. The conditions leading to modifications of this kind are by no means uniform. It may be that the soil is rocky or sandy, so that water quickly drains out of it, or there may be an abundance of water which the roots of the plant cannot readily absorb, owing to the temperature being too low, or perhaps because substances are present which hinder absorption—*e.g.*, common salt and vegetable acids, as in peaty ground. Conditions above ground may also tend to bring about loss of water by transpiration at a greater rate than can be compensated by taking it up from the soil, as when the air is hot and dry, or there is an excess of light.

Plants of Deserts and Steppes. A well-developed system of roots, often extending very far into the ground, is typical of the plants which live in deserts and steppes, for such an arrangement is clearly necessary to suck up the scanty moisture available. In order to check transpiration, a reduction of surface is commonly brought about by reduction of leaves, and in such plants as cacti these are represented by prickles or spines, while the stem swells up and does the work that leaves usually perform [92]. The date palm, and various other plants associated with desert conditions, possess well-developed leaves, but these are covered with a tough and leathery skin, which prevents excessive evaporation of moisture.

The production of spines, thorns, prickles, and the like, is very characteristic of many plants living under arid conditions, and this has a two-fold explanation. It serves as a means of protection against browsing animals, and is also related to the reduction of surface brought about by the necessity for hindering loss of water. Illustrations are afforded by the Australian scrub and the thorny thickets of Africa.

In dry climates the leaves may assume a vertical position, which clearly checks transpiration by minimising the influence of the scorching sun. A similar arrangement is seen in the compass plants (*Silphium*) of North America, the flat surfaces of which face east and west. The excessive heat of the noonday sun is thus avoided, while the most is made of light which falls upon the plant earlier and later in the day.



92. MELON CACTUS

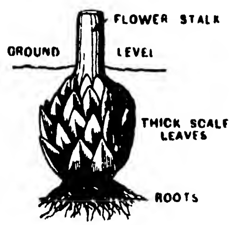
When the supply of water is scanty, it is often stored in underground shoots, such as bulbs and the like. There are South American and African plants allied to our wood-sorrel (*Oxalis*), in which the plant burrows underground during the dry season, and stores up water in its thickened scaly stem.

Moorland and Heath Plants. Many of these are xerophytes, for, where the ground is rocky, there is apt to be little water, and where it is swampy the presence of vegetable acids interferes with absorption. We accordingly find the root system well developed, while the leaves are often specialised so as to prevent undue evaporation. In gorse (*Ulex europæus*), for example, they are converted into spines; while in heather (*Calluna vulgaris*) and the various kind of heath or bell-heather (*Erica*), they are tough and somewhat narrow. Such leaves are usually grooved on their under-side, or rolled [93] in that direction, the meaning of this being apparent when we remember that the little holes (*stomata*) in the epidermis, through which transpiration mainly takes place, are on this

93. HEATH LEAF (cross-section)

side. For in dry, hot weather undue loss of water from this process needs to be prevented, and the grooving, or rolling, marks out a space in which the air is comparatively still, so that transpiration is much less rapid than if the stomata were exposed to the wind. When the moor is soaked by drizzling rain or drenched in fog, there is, on the other hand, a danger lest transpiration should be too much reduced, but the device described keeps the stomata dry, and enables them to discharge their office.

Seashore Plants. Many of these exhibit the same kind of modification which distinguishes plants growing in arid regions. It is true there is no lack of moisture, but the amount of salt present renders absorption difficult. Hence arise a well-developed root-system and over-ground parts adapted to reduce transpiration. Sometimes the leaves are leathery and prickly, as in sea-holly (*Eryngium*); while often they are thick and succulent, for the purpose of storing water, as in seawort (*Honckenya peploides*) and scurvy grass (*Cochlearia officinalis*).

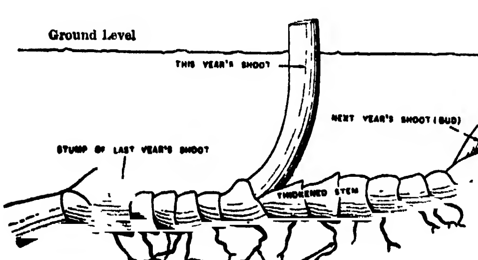


95. LILY BULB

In Alpine and Polar plants, again, we may find similar modification to those just mentioned, for a low temperature is unfavourable to absorption, and it is necessary to husband any water which may be taken up.

When there is a sharp alternation between summer and winter, or between wet and dry seasons, plants have to adjust themselves to different conditions at different times of the year. We may take as an example the winter modifications of a temperate climate such as our own.

Fall of the Leaf. This is not so much due to the direct action of cold as to its influence in more or less checking absorption of water from the soil. The supply of moisture being reduced, it is necessary for transpiration from the leaves to be correspondingly diminished. In such plants as pines and firs we find the evergreen condition, the leaves being only gradually shed. But as these leaves are very narrow, and covered with thick epidermis, there is no danger of an undue amount of transpiration.

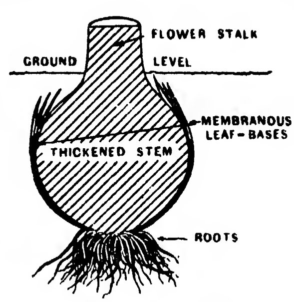


97. SOLOMON'S SEAL RHIZOME

It is far otherwise with the thin and comparatively delicate leaves of ordinary forest trees, which transpire on such a large scale that to retain them throughout the winter would be too dangerous. They are therefore discarded altogether. We have, in fact, the "fall of the leaf." This, of course, involves some waste of material, though not so much as might be imagined; for the advent of autumnal coloration is associated with the withdrawal of much of the living substance of the leaf into the twig on which it grows. This having been accomplished, a layer of cork is formed transversely at the base of the leaf-stalk, and the dead leaf readily falls off. The cork which covers the "scar," being of close texture and of waterproof nature, prevents evaporation, and stops the entry of disease germs. The same is true of the layers of cork which make up the dry outer part of the bark, by which the trunk and branches of the tree are invested.

94. HORSE CHESTNUT
Autumn twig

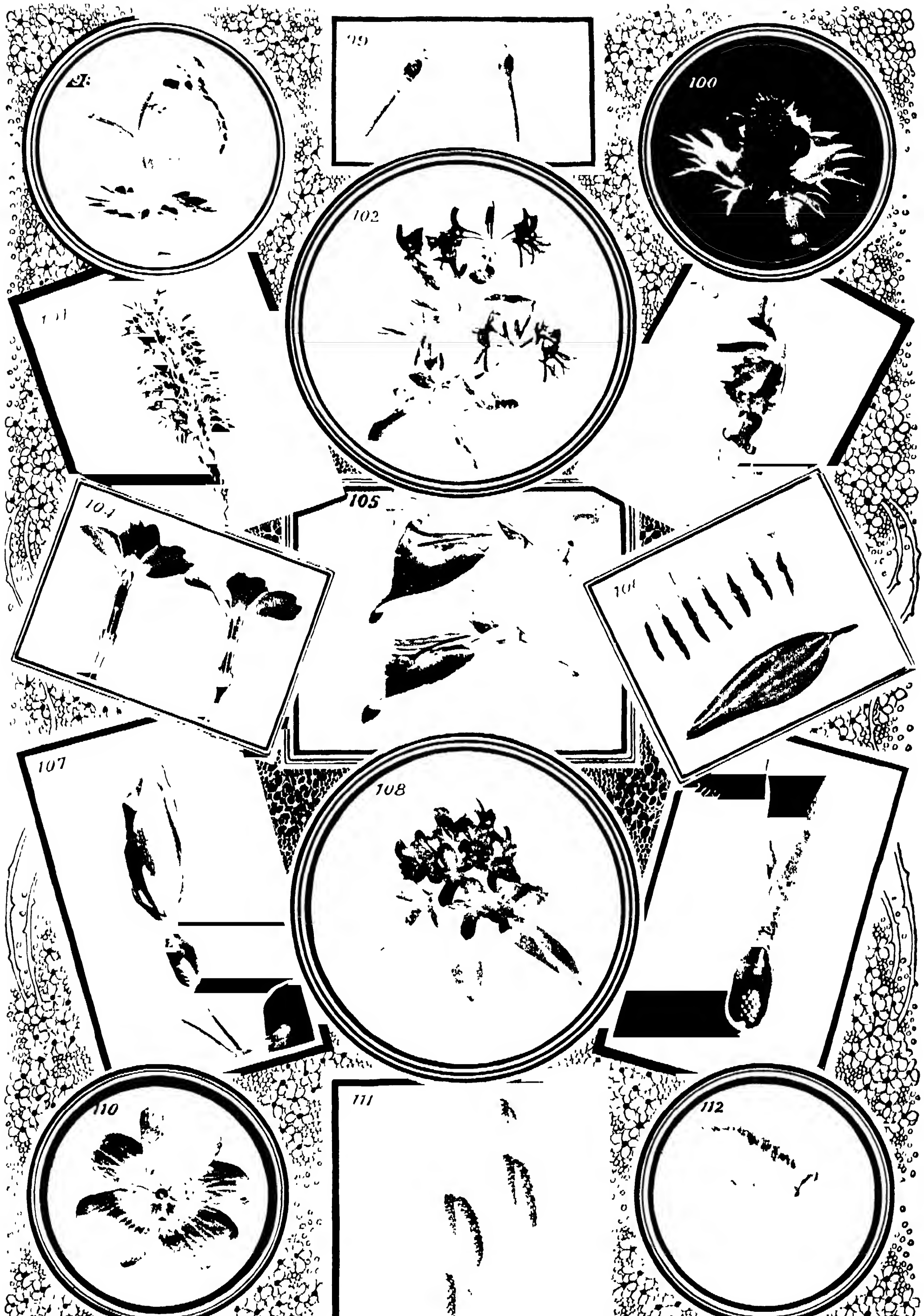
The leaves which are to make up the foliage of the following spring are formed before the onset of winter [94]. They are neatly packed up in winter buds, covered by firm protective scales, often of resinous nature. Cold and wet are thus excluded, and a further sheltering arrangement is often found within the scales in the form of woolly hairs, which invest the tender leaves as in a winter quilt.



96. CROCUS CORM
Section

Winter Storage of Food. In order to start work in the spring without delay, before the time when food is easily obtainable from the exterior, and while the young leaves are unfolding, a store of nutritive matter has commonly been laid in during the preceding summer. Sometimes such substances are stored above ground, as in the trunks of trees. Sometimes they are stored below, as in the thickened *bulbs* of lily [95], or *corms* of crocus [96], which are really underground shoots, as are the thickened *tubers* of potato and the pale subterranean *rhizomes* of iris or Solomon's seal [97]. Not infrequently a thickened root is the receptacle, as in turnip, carrot, and radish. These last-named plants are good examples of *biennials*—*i.e.*, they live but for two years, during the first of which they accumulate their store, while during the second they produce flowers and fruits.

We have already considered the structure and nature of seeds, which may also be regarded as a device for tiding over the unfavourable season of the year. Annual plants, the lives of



Photos by] **FLOWERS FOR WHICH WIND AND INSECTS WORK** [Prof. B. H. Bentley, M.A.

(98) Butterfly sucking Everlasting Flower (99) Female flowers of Hazel. Projecting stigmas catch pollen blown by wind [see 111]. (100) Bees sucking Sea-holly. (101) Timothy Grass in blossom. Below: young flowers with projecting stigmas, and above, older ones with long, slender stamens. The pollen is carried by wind. (102) Honeysuckle, which attracts hawk-moths, which carry pollen. (103) Bee sucking Hyacinth. (104) Sections of "thrum-eyed" [to left] and "pin-eyed" [to right] Primroses. (105) Sections through two stages of Foxglove. In the younger flower [above] the anthers are shedding pollen and have shrivelled in the older flower [below]. (106) Stages in development of disk-floret of Sunflower. Below is a sterile ray-floret, which acts as a "signal flag" (107) Common Arum in first stage. "Insect trap" at lower end is cut open. (108) Rhododendron, showing nectar-guides as streaks on upper part. (109) Common Arum in second stage. "Trap-hairs" have withered [see 107]. (110) Hellebore or Christmas Rose, with petals modified into tubular "nectar cups." (111) Male flowers of Hazel, arranged in catkins, from which pollen is easily blown [see 99 (112 Bee sucking nectar from flowers of Willow

which do not extend beyond a single year, are commonly represented during midwinter by seeds alone.

Water, Wind, and Animals. If the egg-cells of a flower are fertilised by the agency of pollen from the same flower, they are said to be *self-fertilised;* if by pollen from another flower, *cross-fertilised.* As in the latter case healthier and more vigorous seeds are produced, it is not surprising that it should have been favoured in the course of evolution, and that innumerable devices should have come into existence by which self-fertilisation is hindered and cross-fertilisation promoted. Such devices very largely have reference to the process which precedes fertilisation—*i.e.*, *pollination*, the transfer of pollen to the stigma, or, in naked-seeded plants, direct to the ovules. They more or less prevent *self-pollination* and facilitate *cross-pollination.*

Since pollen-grains are not themselves capable of movement, it is requisite that, to secure crossing, they should be transferred by some outside agency from the anthers of one flower to the stigmas of another. This transference may be effected by water, wind, or animals, the last, of course, carrying out their important work quite unconsciously.

Water as a Pollen Carrier. In certain aquatic plants the movements of the surounding water bear the pollen to its destination. The best example is probably that of Vallisneria [**118**], commonly grown in aquariums in this country. Self-pollination is entirely prevented by a method which is adopted by many other forms. The stamens and carpels are developed in different flowers, which grow upon separate plants. The female flower is placed at the end of a spiral stalk, which uncoils when it is ready to open, and brings it to the surface.

Meanwhile the ripe male flowers have separated themselves from their stalks, and, being lighter than water, float about like so many little boats, being drifted here and there by the wind. Their perianths expand and the stamens project, lifting up their anthers so that the pollen is kept dry. Should one of them be driven against a female flower, some of the pollen is likely to adhere to the sticky surface of one or other of the three projecting stigmas, and thus cross-pollination is brought about. When the egg-cells are fertilised, the stalk of the female flower coils up again, so that the seeds mature in a sheltered situation, where they are safe from the attacks of seed-eating animals.

How the Wind Carries the Pollen. In the case just dealt with, wind plays an important part in the transfer of pollen, and in many land-plants it is the sole agent. The cone-bearers (*Coniferæ*) rely upon it for the discharge of this important office, and we may take the Scotch pine (*Pinus sylvestris*) as a common type. Here, again, self-pollination is entirely prevented by the flowers being of two kinds, male and female, which are borne on the same tree.

As is usual in such cases, vast quantities of dust-like pollen is produced, in order to ensure that some of it should be carried to the ovules, for in plants of this kind there are no stigmas. In some years the amount produced in forests of pine or fir is so enormous that the ground is thickly covered with the yellow dust. This is the origin of the so-called "sulphur showers."

Transfer by wind is facilitated by the fact that two little air-filled bladders are attached to each pollen-grain [**114**]. At the time when the pollen is shed, the ovule-bearing scales of the female cone are slightly separated, and a sticky fluid exudes from between them. By this the pollen-grains are caught, after which it gradually dries up and draws them down to the ovules, so that they can perform their office.

Hazel a Good Example. Most of the ordinary trees of temperate regions are also wind-pollinated, and open their flowers in spring before the new leaves have emerged from their buds, and when, therefore, the pollen-grains are most likely to get blown to the stigmas. A conspicuous example is hazel (*Corylus Avellana*), where the flowers are once more of two kinds borne upon the same plant. The male flowers are aggregated into long, pendulous catkins [**111**]—popularly known as "lambs' tails"—and are easily shaken by the slightest breeze, by which their dust-like pollen is carried away. The female flowers are in bud-shaped groups, from which the sticky pink stigmas project [**99**].

A number of herbs with inconspicuous flowers are also pollinated by means of wind—*e.g.*, many grasses. We may take Timothy grass (*Phleum pratense*) in illustration, for it presents us with many points of interest. The numerous flowers are here closely packed into an elongated spike [**101**], and though each of them contains stamens and pistil, there is a special arrangement by which self-pollination is hindered. In the lower part of the spike we shall find the younger flowers, with stamens still unripe, but mature stigmas projecting to the exterior ready to catch any pollen that may chance to be blown against them. The stigmas of the older flowers in the upper part of the spike have for the most part done their work and shrivelled up, while the stamens are now mature. The anthers are so attached to the long, slender filaments that they are shaken by every breath of air, and their pollen easily dispersed. Another very interesting device is found in the wind-pollinated flowers of nettles, for the ripe stamens uncoil like springs and launch the pollen on its course.

Flowers and Their Bird Friends. Pollen may be transferred unconsciously by mammals, birds, snails, and insects, about each of which it will be necessary to say something.

One of the trees (*Freycinetia*) native to Java bears flowers with beautiful pink petals, which are eagerly devoured by the kalong, or fruit-bat (*Pteropus edulis*), and there can be no doubt

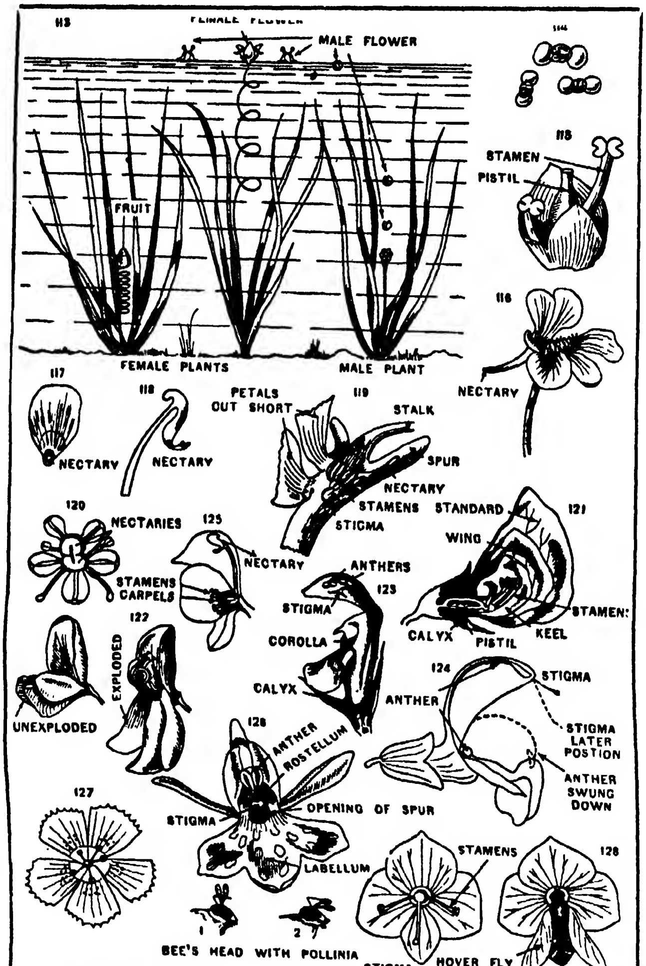
that the pollen of the male flowers which adheres to the furry snout of this animal is carried to the stigmas of the female flowers. It also appears that certain insect-eating bats in the West Indies hunt for their prey among the blossoms of certain trees, and transfer pollen in the course of their feeding operations. In Australia it is not impossible that the flowers of a common shrub (*Dryandra*) may be cross-pollinated by the agency of kangaroos.

The beautiful little humming birds (*Trochilidæ*) of America, the sun-birds (*Nectariniidæ*) of Africa, which resemble them in appearance and habits, and some few other forms, visit flowers for the sake of the sweet fluid (nectar) they contain and possibly also in the search for small insects. Such flowers are relatively large and conspicuous, and commonly of a bright scarlet hue. Those visited by humming birds are bell-shaped and pendant. Their shape is adapted to that of the heads of their guests. The work of humble slugs and snails is very important in the process of nature. Some of these voracious creatures visit certain plants with inconspicuous flowers which grow in damp places, and drag along pollen-grains in their slime from one blossom to another. Such is the case with the little golden saxifrage (*Chrysosplenium*), common in the neighbourhood of springs, and also with duckweed (*Lemna*), the small floating plants of which so commonly cover stagnant ponds and ditches with a continuous sheet of green [115].

The vast majority of conspicuous flowers are cross-pollinated by the agency of insects, and in the course of evolution an immense number of mutual adaptations have arisen between them. [See **100**, bees sucking sea-holly; **103**, bee sucking hyacinth; **112**, bee sucking flowers of willow; **98**, red admiral butterfly sucking everlasting flowers.]

The Three Kinds of Flowers. In some cases we find that, as in Scotch pine and hazel, the stamens are borne in separate flowers, which may be on the same or on different plants. Wild arum (*Arum maculatum*) [107 and 109] illustrates the former condition, and willow (*Salix*) the latter. Various compromises are also possible by ringing the changes on the three possible kinds of flower—*i.e.*, hermaphrodite (with both stamens and pistil), male and female. A given species may possess hermaphrodite and either male or female flowers, or, again, all three kinds may be present. The modes of distribution in such plants are also extremely varied. Male and female flowers may arise from hermaphrodite ones by suppression of pistil and stamens respectively.

In most flowers both stamens and pistil are present, but it by no means follows that self-pollination takes place, for, as already described for Timothy grass, the stigmas may mature before the pollen is shed, though the opposite state of things is more commonly true, as in



113. Vallisneria. 114. Pollen-grains of pine (magnified). 115. Duckweed flower. 116. Indian cress. 117. Buttercup petal. 118. Monkshood nectary. 119. Violet (section). 120. Hemlock. 121. Sweet pea (section). 122. Broom flowers. 123. Dead-nettle flower (section). 124. Meadow sage. 125. Monkshood flower (section). 126. Bee's head with pollinia. 127. Pink (ripe stamens). 128. Speedwell

monkshood (*Aconitum*). Besides which, it very often happens that the anthers and stigmas are so placed in relation to one another that self-pollination is impossible. Some flowers are also *self-sterile—i.e.*, if pollen reaches the stigma of the same blossom it is not able to bring about self-fertilisation. We shall see later, however, that self-pollination may be possible from the first, or may be effected as a last resort, or may even be provided for by special contrivances.

How the Flowers Invite Insects. The two chief means are colour and odour. The colour depends upon the nature of the guests to be enticed. White and yellow appear to be agreeable to a large number of small insects belonging to various groups, which visit such forms as cow parsnip (*Heracleum*) and buttercup (*Ranunculus*). A pale or white tint is also characteristic of flowers which open in the evening and cater for moths, and it clearly renders them as conspicuous as possible. Red attracts butterflies, and brownish-red is preferred by wasps, while purple and blue appeal more particularly to bees and hover-flies. Dull red and livid colours, especially when arranged in spots or blotches, are affected by flies which like carrion and other noxious substances.

Flowers of small size may be rendered conspicuous by being crowded together in large numbers, as in elder (*Sambucus*), the carrot and parsnip order (*Umbelliferæ*), and the dandelion order (*Compositæ*). The last case is particularly instructive, for it includes a variety of specialisations of different kind. The individual florets which make up the head may be all regular, as in thistles; all irregular—*e.g.*, dandelion (*Taraxacum*); or, again, the inner disk-florets may be regular, while the outer ray-florets are irregular, of which condition, sunflower (*Helianthus annuus*) [**106**, lower figure] and daisy (*Bellis perennis*) afford examples. The irregular ray-florets have given up the function of producing seeds, and may be regarded as "signal flags," by which the conspicuousness is greatly enhanced. Allusion has elsewhere been made to the odours of flowers.

The Flower's Reward to Invited Guests. These are chiefly pollen, nectar, and sweet sap. Pollen flowers, of which red poppy (*Papaver Rhoeas*) and potato (*Solanum tuberosum*) are examples, offer only the first kind of reward; while nectar flowers, as their name indicates, afford the second, and often pollen in addition. Our common British orchids are visited by insects which bore for sweet sap.

Nectar may be secreted by nectaries situated in various parts of the flower, and differing greatly in shape and character. In the wallflower order (*Cruciferæ*) they are in the form of little fleshy projections of the floral receptacle, and in the dead-nettle and foxglove orders (*Labiatæ* and *Scrophulariaceæ*) they belong to the same region, and are in the form of a fleshy ring at the base of the pistil.

The pointed spur at the back of an Indian cress flower (*Tropæolum*) [**116**] is a nectary belonging to the calyx. In a very large number of instances the petals secrete nectar, and an instructive series of cases is presented by flowers of the crowfoot order (*Ranunculaceæ*). In buttercup (*Ranunculus*) there is a nectar pit covered by a little scale at the base of each petal [**117**], while in columbine (*Aquilegia*), Christmas rose (*Helleborus niger*) [**110**], larkspur (*Delphinium*), and monkshood (*Aconitum*) [**118**], all or some of the petals are converted into tubular nectaries of various shape. Sometimes the stamens undertake the work of nectar production, a pretty instance being that of violets and pansies (*Viola*) The nectaries are here a pair of threads, which grow back from the two lowest anthers [**119**], and project into a spur belonging to the undermost petal, which serves to store up the sweet fluid until insects come to probe for it. And, lastly, nectar may be secreted by the pistil, as in the carrot and parsnip order (*Umbelliferæ*), where the nectaries are represented by a swelling on the top of the ovary [**120**].

The Insect's Guide to the Treasure House. If an insect is to do its work of transferring pollen successfully, it often happens that it must make its visit to a flower in a particular manner, which involves going straight to the nectar, without waste of time in hunting round. Hence have been evolved nectar guides, in the form of streaks, spots, or blotches, which indicate the position of the coveted treasure. In rhododendron [**108**], for instance, there are streaks on the upper part of the corolla, which converge to the opening of the cavity where nectar is stored.

In a large number of small regular flowers, mostly of white or yellow colour, which cater for a miscellaneous crowd of short-tongued insects, the nectar is fully exposed to view. We find this state of things in most members of the parsnip and carrot order (*Umbelliferæ*), and in some saxifrages. Not unlike these, but somewhat more specialised, are flowers which partly conceal their nectar, and lay themselves out for a rather more select circle of guests with somewhat more elongated mouth parts. Such are most members of the wallflower order (*Cruciferæ*), buttercups (*Ranunculus*), stitchworts (*Stellaria*) and their allies, barberry (*Berberis*) and cinquefoil (*Potentilla*). And, lastly, we have flowers which completely conceal their nectar in deep recesses or long spurs [**116** and **118**], and attract the most intelligent and highly specialised insects, such as bees and butterflies, in which the mouth-parts are drawn out into a long proboscis that forms a very efficient sucking organ. Many such flowers are irregular, and adapted to the shapes of particular guests; while red, blue, and violet are the favoured, though not the only colours. Here belong foxglove (*Digitalis*), honeysuckle (*Lonicera*), larkspur (*Delphinium*), and monkshood (*Aconitum*), together with the orchids, which offer sweet sap instead of nectar.

To deal fully with the innumerable arrangements for cross-pollination would occupy a large volume, and it will be possible here only to describe briefly a few of the more interesting native forms which are visited by the higher insects.

THE PRACTICE OF DRAIN LAYING

Intercepting Chambers. Manholes. Laying the Pipes. Iron Drainage. Stable Drains. General Arrangement of Drains

Continued from page 573

By Professor R. ELSEY SMITH

Laying Drains. We have now to consider how the various fittings already described are combined into a complete drainage system, and it will be convenient to look at the work of drain-laying before referring to the preparation of a drainage plan. For the moment, we shall assume the existence of such a plan on which the drains and all fittings are shown and on which the levels of the sewer and the inclination of the drains are fixed.

The laying of the drains is often deferred till other work in the building is far advanced, but it involves a large amount of excavators' work, and will now be described. The first operation is the excavation and strutting of the trenches, which in most cases are made of the minimum width in which a man can work. The bottom is carefully levelled to the falls shown upon the drawings—not stepped as in the case of trenches for walls—and where it is required a layer of Portland cement concrete is spread evenly over the bottom of the trench. Concrete is always desirable, but some local authorities do not insist upon it under rain-water pipes. The concrete should be 6 in. deep and should extend for a width of 6 in. beyond the outer face of the pipe on each side. The lower 6 in. of the trench should be excavated to the exact width required for the concrete, even if a greater width for working be necessary higher up. The concrete slabs on which the manholes are to be built are also put in. They are usually 9 or 12 in. thick and extend beyond the outer face of the manhole for about 9 in on all sides. Layers of concrete are also required under traps and gullys.

Connection with Sewer. The actual connection with the public sewer, for which purpose junctions are often built into the sewer, is usually made by the local authority, who bring up the branch drain to the point where the private property abuts on the road. The laying of a drain begins from the lower end, and the spigot end of a pipe should always be the lower. Every drain should be laid in a perfectly straight line from manhole to manhole, or from any gully or trap to the manhole. The fall in the same distance should also be absolutely uniform. The reason for this is, that in a drain so laid it is possible, with the help of a mirror, to see through it from manhole to manhole and to detect at once the position of any obstruction.

The illustration [35] shows a plan of a town house of considerable size and the method of draining it. Fig. 36 shows the plan of a large country house. In the latter there may be a considerable length of drain beyond that shown, so as to carry the system to a sewer or to the point where the sewage is to be dealt with, but the construction will be similar, lampholes and manholes being provided alternately at intervals.

Forming the Intercepting Chamber Floor [37]. The footings and wall of the chamber must be raised to the levels at which the drains enter it. The intercepting trap is fixed at its proper level standing on a bed of concrete and set in concrete. The necessary channels are selected from the list of the maker whose goods are specified, and are first put together dry, to see that they fit properly the positions for which they are intended, and are then laid on fine concrete, the joints being left free till they have been very carefully made in cement. The main channel is jointed to the upper end of the trap, and if this channel can be obtained in one length, the upper, or socket, end receives the main drain from the building. In a large manhole the channel may be in two or more lengths, jointed. The channels from the branch drains, if any be required, are then fixed. The bottom or invert of each discharges into the main channel, and the upper end of each is jointed to the branch pipe. When these are fixed, fine concrete is filled in between the channels, care being taken not to break the joints, and is banked up from the edges of the channels to the side of the chamber. In the case of a chamber receiving several branch drains at the sides, the banking must be curved to conform to the various branch channels, and often forms a somewhat narrow tongue between two curved channels. All this work requires great care, as the slightest flaw may allow the escape of water and result in the chamber being condemned. This banking is finally finished with a smooth trowelled face with Portland cement mixed with a little sand.

In order to avoid the complicated work of forming the bottom of a manhole as described, manufacturers now provide channels and junctions in one piece, suited to a variety of combinations. These may be utilised to form the bottoms of manholes. Some of these are also provided with covers [33, 34] to close the channels and prevent any possibility of the solid matter carried in the sewage being washed out of the channel by a sudden flush, deposited on the banks, and then left to decompose. Even when this is not provided, the fact that the bottom is in one solid piece, without a multiplicity of joints, is an advantage, but the fact of its being so may sometimes interfere with the nice adjustment of the drainpipe to the channel, possible in the ordinary method.

Building the Manholes. When the channels are set they are protected with boards, and the manhole or chamber is built up by the bricklayer to the level of the ground. If it is deep, he builds into one side or angle a series of iron steps or bars, called *climbing irons*, to render the bottom of the m nhole accessible when necessary for inspecting or cleansing the drains. The size and form of a manhole depends on the number of drains which enter it, but, except in the case of a very shallow one, it should not be less than 2 ft. 6 in. in length or width, or it is difficult to use cleaning rods. The top may be contracted by means of oversailing courses [see BRICKLAYER], or it may be covered with a single slab of stone [Fig. **31**, page 571], which is perforated and rebated [see MASON] to receive the *manhole cover*.

The Manhole Cover. The manhole cover consists of an iron frame (which should be galvanised) with a flange, which is bedded in cement on the brickwork top or in the rebate of the stone. There is a groove running all round the frame, and the top or cover has on its under side a flange which fits into the groove and seals the manhole. When closed, this groove may have sand or water placed in it to make an air-tight joint, but the best method is to make a joint with Russian tallow, though other compositions are used. The object of making the cover air-tight is to prevent the escape of sewer gas and for additional security double covers are often arranged for and should be used wherever a manhole has to be constructed within a building.

The cover, usually loose, is in some cases screwed to the frame at the angles; but if this is done, the holes must not be placed inside the frame, or, in the event of one of the screws being left out a free passage for sewer gas is provided. The top should be secured to a lug or flange outside the grooved channel. The walls of the manhole are often rendered in Portland cement [see PLASTERER] for the lower part or to the full extent of their height. In the best class of work, interiors of manholes are often built with glazed bricks.

Fresh-air Inlet. Every intercepting chamber must have a fresh-air inlet. For this, an ordinary drainpipe is taken into it near the top, which should be of the same diameter as the drain passing through it. This is taken to a selected point and connected with a vertical iron shaft, finished with a box-shaped head [Fig. 32, page 571]: in the front of this one or more diaphragms, formed of thin sheets of mica and hinged at the top, are placed, so that, in the event of there being any pressure of air from the inside, they will close the orifice and prevent its egress, but will readily open to admit fresh air to the chamber and thence to the drain. This apparatus requires periodical attention otherwise the diaphragms are liable to become fixed, and thus permit the egress of sewer gas.

The ordinary *inspection chamber* [**38**] only differs from the intercepting chamber in that it has no trap at the outlet and no fresh-air inlet, otherwise it is constructed in the same manner —a cleaning pipe replacing the intercepting trap.

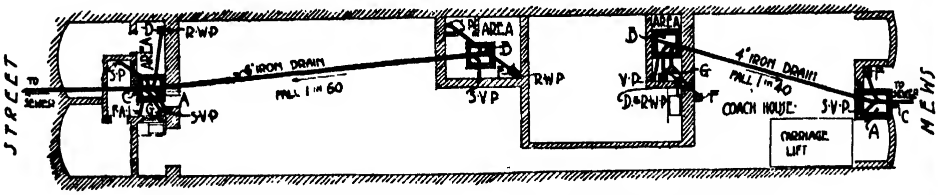
Where a chamber is only required to allow of change of directi n in the drain [**39**, **40**], it may be kept smaller but is in other respects similar.

Lampholes. Lampholes [**41**] are useful in long, straight runs of drainpipes which receive no branch drains, enabling inspection chambers to be built further apart than would otherwise be the case. They are formed with ordinary drainpipes placed vertically over the drain, connected to it with a junction, which in this case must be a right-angled junction, and extending up to just below the ground level. The top is securely closed with a stopper, and may be buried two or three inches under the ground and marked, or—which is a better practice—terminate in a small chamber with a manhole cover. The object of this pipe is to permit of a lamp or candle being lowered to the level of the drain, so that it may be examined from the manhole above or below it in case of an obstruction.

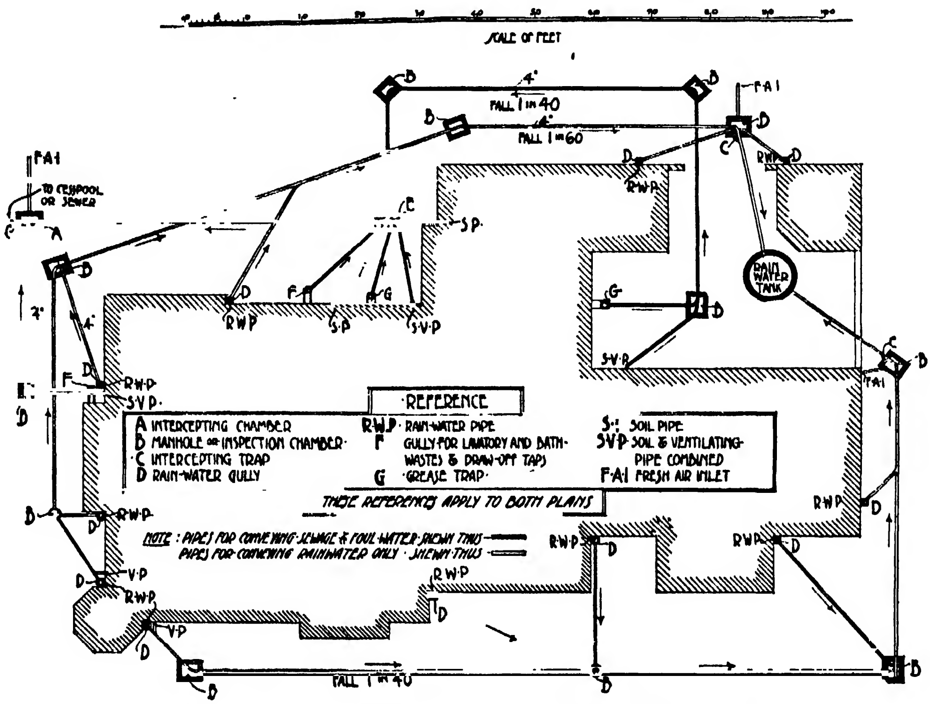
Laying the Pipes. The drain from the intercepting chamber to the next manhole or to a gully, soil-pipe, or ventilating pipe is usually put together dry and carefully levelled. In very good work special chairs of earthenware are used to raise the pipes about 2 or 3 in. from the concrete bed to allow of the joints being made all round, but this is often done with pieces of brick or stone. The ordinary joint is made with Portland cement gauged with as little sand as possible. The socket of one pipe is coated with the material, and also the spigot end of the next pipe, and the latter is then thrust into the socket, care being taken to see that it is properly centred and goes well home and that the joint is at all parts well filled with cement. The joint is afterwards carefully smoothed externally with a trowel and finished with a splayed surface or collar [**13**, **14**, page 571]. The inner face of the joint is also carefully cleaned, the workman thrusting his arm into the pipe and wiping off any cement which may be forced up between spigot and socket of the two pipes, and which, if allowed to remain, would obstruct the flow of the sewage.

A *badger* is sometimes employed in this operation. It consi ts of a block of wood smaller than the pipe, but with a rubber edge and a wire handle. It is placed below the joint before it is made, and afterwards withdrawn, bringing away any cement. Every pipe should be separately laid so that this operation may take place. If two pipes are joined before being laid in the trench, the total length will be found to o great to permit of it Joints between pipes and channels or gullies are similarly made, and in any case where an inspection or cleaning eye is introduced the run of the pipes from this point to the next manhole should be perfectly straight and the fall perfectly even, as described, between manholes.

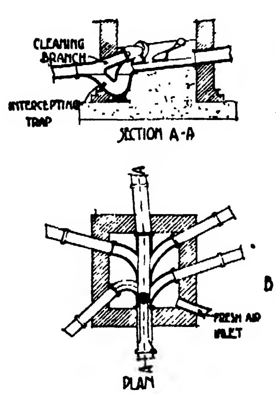
Special Joints. Other forms of joints are used between pipes. One of the most usual



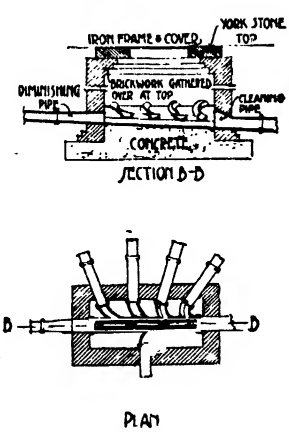
35. Block Plan of a large Town House and Stables, showing Drainage.



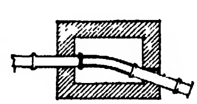
36. Block Plan of a large Country House and Offices, showing Drainage.



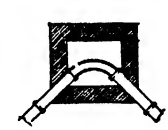
37. Intercepting Chamber.



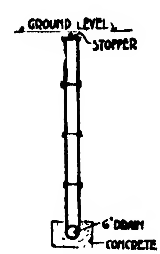
38. Inspection Chamber.



39. Small Chamber for Bends without Branch Drains.



40. Small Chamber for Bends without Branch Drains.

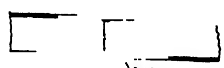


41. Lamphole.

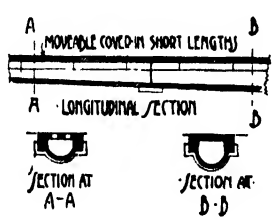
is known as Stanford's joint [15, page 571], the patent for which has expired. In this joint the socket is lined with a compo ition formed with 1 part of clean sharp sand, 1 part of boiled tar, and 1½ parts of sulphur. The surface is slightly bevelled, the spigot has a band of the same composition slightly rounded, and the two when brought together form a close joint which ensures that the pipes are truly centred. The surface of the joint is smeared with tallow before the pipes are fitted, and the spigot end must be driven well home to ensure a close internal joint. The outer edge of the joint is often finished with a cement collar. Another form of joint has the composition cast on in the form of a screw, the pipes being screwed together in fixing. A thin layer of cement composition is used with this joint.

A special joint for pipes with a deep socket is formed with two separate rings of composition with a clear space between. After the pipes are put together this space is filled with liquid cement from a hole at the top formed for the purpose. This forms a strong water-tight joint. Where a drainpipe is to be connected with a vertical soil or ventilating pipe—a connection which must always be direct, without any trap or gully—a bend must be used to connect the inclined drain and the vertical pipe. The end of the pipe, if of iron, is inserted into the socket of the bend and the joint made in cement. If the pipe is a lead one the end has a ring of brass, termed a *sleeve* or *ferrule*, fixed on its outer surface before the joint is made [see PLUMBER].

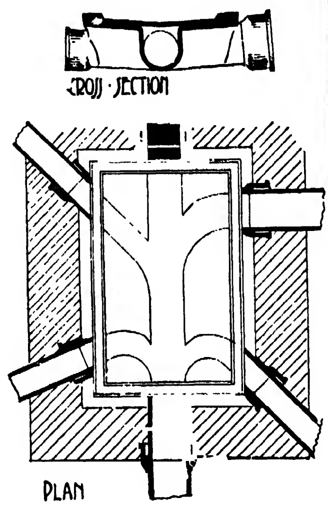
When any section of a drain is completed it should be at once tested as hereafter described. If every joint is found to be absolutely sound and no leakage occurs, concrete may be filled in around the pipes very carefully. Each joint must be examined, the upper surface by the eye, the lower surface by placing the hand below to see if there is any moisture exuding from the joint. The concrete is filled in under the pipes and the chairs or bricks used to raise the pipes are left in position. The concrete is in most cases filled in till the crown of the pipe is covered with 6 in. of it. Great care must be exercised in depositing the concrete, as any serious jar may break one of the joints, and when re-tested after the concrete has set the length may not hold water and have to be taken up and re-laid. The trench above the concrete should not be filled in till this re-testing has been done, for should a defect be found the labour will be thrown away.



42. JOINT FOR IRON PIPES.



44. SECTION OF AN IRON STABLE CHANNEL.



43. IRON MANHOLE WITH SIDE INLET.

Iron Drainage Fittings. In addition to the various forms of earthenware goods hitherto described, cast iron is employed a good deal. In any drainage scheme which involves carrying a drain under a building, the local authorities usually enforce the use of iron pipes of heavy quality for such parts of the work as pass under the buildings.

Iron pipes are described by the weight in lb. per yard run. The following weights are usual for house drains: 4 in., 54 lb.; 5 in., 72 lb.; 6 in., 91 lb. The pipes used for this purpose are cast with deep sockets at one end, and a small projecting bead at the other. They are made in longer lengths than stoneware pipes, and are usually 3, 6, 9, or 12 ft. long. The iron drain should extend from manhole to manhole, to avoid joining them with stoneware pipes, and the joints are made by inserting in the sockets of each pipe a ring of tarred yarn, then running in "blue" lead, so called to distinguish it from white or red lead. Blue lead is melted and poured into the joint, and afterwards caulked or hammered [42].

It is becoming increasingly common to use other fittings of iron, and to carry out entire systems of iron drainage. For this purpose not only pipes, but all the parts and fittings already described as of stoneware are now also made in cast iron.

Makers now manufacture intercepting and inspecting manholes cast in one piece. These consist of shallow iron frames or boxes [43] within which the channels are formed, and outside which the various sockets for receiving the main and the branch drains are cast in at the required angle. An outlet or spigot end is also cast on for jointing to the drain below. The channels may be half round, or they may be extra deep, equal in depth to the diameter of the pipe. These

chambers are stocked in a great variety of forms to suit various sizes of drains, and fitted with branches of various sizes and at various angles. Any combination not stocked can usually be supplied with little delay.

The manhole and all its branches must be set out, and the angles at which they enter measured, before the manhole is selected or ordered. When this is done, no difficulty should arise in fitting up. The great advantage of such a manhole is that, being in one piece, there is no possibility, if the casting is sound, of a leak within the manhole itself, and it is provided with a top resembling an ordinary manhole cover, fitting into a groove and secured into position, which renders the manhole both gas and water tight. There is no possibility, therefore, of sewage overflowing the channels and decomposing, as in an ordinary manhole. Such a manhole, including the cover, is only a few inches deep, and must be placed within a chamber for easy access, but the chamber need not be constructed with the same care as is necessary when an open drain passes through it.

The advantage a complete system of iron drainage possesses over earthenware is in its greater power to resist the disturbing influences due to settlements, vibration, or any external pressure under which an earthenware pipe might be cracked, and allow leakage. The surface of the iron must be protected from corrosion. This is generally done by a coating of *Dr. Angus Smith's Solution*, which consists of a mixture of coal-tar and pitch, with about 5 per cent. linseed oil, and sometimes a little resin, the whole heated to a temperature of about 300° F. The iron to be treated is plunged into the mixture and left in till it attains the same temperature, then removed, and allowed to cool in a vertical position. The best results are held to be obtained when the iron, before insertion, is heated to a tempreature of about 700° F., but this increases the cost. Glass-lined or enamelled iron channels and pipes are used sometimes, but are expensive.

The small size of the manholes used in iron drainage systems, which are in some ways advantageous, have this drawback, that in the event of the outlet being temporarily stopped, owing to the sewer being fully charged, there is very little space in which the water collected by the drain can accumulate, and it will speedily overflow; whereas the large cubic space provided in a deep manhole may, under such circumstances, temporarily accommodate the drainage till the stoppage is removed.

Stable Drainage. Stable drains are of a special character. Within the stable itself they are designed to collect and remove from every stall and loose-box the horses' urine. It is not desirable that the floor surface of the stalls should have any great inclination, nor should channels into which a horse might tread be left open.

Stoneware channels are liable to breakage, and all such drainage is best executed in cast-iron channels, the depth of which is regularly increased, so that the fall is obtained in the channel itself, while the top is kept at a uniform level, or nearly so, and may be covered with strong perforated cast-iron plates [44]. The channel may, in most cases, be run to the external wall, and discharged into a stable gully placed outside. Where this is not possible, traps, with strong iron covers, may be provided, and an underground iron drain taken outside the building.

The covers to channels and traps are easily removed for cleaning, but cannot be disturbed by the horse. Open iron gutters are also sometimes used. They consist of several small shallow parallel channels with ridges between, which are arranged to give a foothold to the horses. All iron work to be laid in a stable floor must be provided with a roughened surface, to give a foothold. Channels are sometimes formed in concrete, with iron kerbs built in on either side to receive the necessary covers.

General Arrangement of Drainage. The drainage of individual buildings as applied to systems of water-borne sewage, with few exceptions, depends upon the action of gravitation, and in arranging a system of drainage this circumstance must not be lost sight of from the first. Care must be taken to see that the levels of the building or site to be drained are such as to allow of the drainage being taken to the public sewer, or to any other required destination with a sufficient fall to ensure its efficient action. In the case of water not carrying sewage, such as water collecting in foundations, it may, if necessary, be collected into a *sump*, which is a chamber sunk below the level to which the water rises, and in which it collects, and from which it may be pumped up so as to flow into a drain; but even this is undesirable, as it means frequent attention and expense. This system is not applicable to sewage from private buildings, but it is sometimes employed on a large scale in sewerage systems.

Detailed Arrangements of Drainage. These vary so greatly under different circumstances that it will be possible only to refer to the general principles involved. The first matter to be determined is the ultimate destination of the sewage or water to be dealt with, and the level of the outfall of the drain. Where the difference of level between the lowest part of a building to be drained and the outfall is ample, it removes what may be a serious difficulty should there not be depth for an adequate fall in the drains.

Self-cleansing Drains. For a drain to be self-cleansing the liquid in it should flow with a velocity of at least 3 ft. per second. The velocity is considerably reduced when the drain is only filled to a small proportion of its capacity, which is the usual condition of domestic drainage, and most local authorities require a sufficient fall to give a velocity of approximately 5 ft. per second when the drain is running half full.

A table of the approximate inclination to which drains must be laid to secure various velocities when flowing *half-full*, and the number of gallons discharged per minute when flowing *full* bore *:

* Compiled from tables in Hurst's Architectural Surveyor's Handbook.

Internal Diameter of Pipe.	Inclination.	Velocity in Feet per Second.	Discharge in Gallons per Minute.
2-inch ..	1 in 100	2	16
" ..	1 in 50	3	24
" ..	1 in 30	4	33
" ..	1 in 20	5	40
3-inch ..	1 in 140	2	38
" ..	1 in 70	3	56
" ..	1 in 45	4	73
" ..	1 in 30	5	93
4-inch ..	1 in 200	2	66
" ..	1 in 100	3	98
" ..	1 in 55	4	135
" ..	1 in 40	5	162
6-inch ..	1 in 300	2	150
" ..	1 in 140	3	226
" ..	1 in 80	4	305
" ..	1 in 59	5	370
9-inch ..	1 in 450	2	337
" ..	1 in 220	3	500
" ..	1 in 125	4	687
" ..	1 in 90	5	820

It is not, as a rule, convenient for the invert of the manhole at the head of the drain to be less than 1 ft. 6 in. from the ground level, and the fall being determined and the length of drain set out, the actual levels of the various manholes and of the outlet may be calculated in reference to a fixed datum. When possible, it is desirable to make the fall in the drain follow any general inclination in the surface of the ground, so as to save as much deep digging as possible; but the planning of an efficient drainage system must not be in any way sacrificed to do this. In cases where the sewer is very deep, it is usual to lay out the whole system as far as the intercepting chamber to ordinary falls, and to give the last length of pipe between the syphon trap and the sewer the necessary inclination to make the connection.

Where the depth available is ample, the open channel running through the manhole may be given a sharper fall than the general drain (say, 1 in. in 1 ft.), so that the contents before reaching an intercepting trap may attain extra velocity.

Drains not Self-cleansing. Where the depth between the head of the drain and the outfall is inadequate to give the desired fall, the levels must be worked out very closely, and care taken in planning to make the length of the drain as short as possible. It may be necessary to assist the cleansing of the drain by an *automatic flushing tank* [see PLUMBER] placed at the head of it. Water is allowed to flow into this tank at a regulated speed, and when full it discharges automatically its entire contents rapidly and with high velocity into the drain, thereby scouring it out. The outlet of the tank should be as large as the drain to be flushed, the object being to charge the drain fully. The tank should contain not less than 50 gallons for flushing a 4-in. drain, and the frequency of the flush may be regulated. Tanks with larger capacities may be used, and are necessary for larger drains.

Size of Pipes. The size of drainpipes is regulated by the work they have to do. Where the sewage system is separate the maximum flow can be readily gauged, and, as an example, the regulations of the Board of Education require a 4-in. pipe, unless it is connected to more than ten w.c.'s, in which case it must be 6 in.

If the rainwater is carried by the same pipe there is a liability in times of excessive rainfall for the drain to be choked with water if it is inadequate to carry it off. It is necessary then to calculate the area from which water is collected into the drain, and it is usual to allow for collecting the following quantities of water as the result of rainfall in ordinary districts in England:

From roofs ..	..	0·75 in. per hour.
From paved yards	..	0·75 " " "
From gravel paths	..	0·40 " " "
From meadow land	..	0·10 " " "

Occasionally, for short periods, a fall at the rate of 1 in. and even more per hour may have to be dealt with from roofs.

Position of Inspection Chambers. With a view to economy it is desirable to use as few manholes as is consistent with efficiency, and to converge as many drains as possible at each. In a soil-drain every connection and every change of direction must be made at a manhole [38, 39, 40]. In a rainwater drain the same principle should be observed as far as possible, but if the main run is laid in a straight line to true falls and only conveys rainwater, most local authorities allow junctions to be made with it. When rainwater branches must be taken into a soil-drain, and the connection cannot readily be made in a manhole, a separate rainwater pipe should be laid from manhole to manhole alongside or above the soil-drain, to receive such connections.

Position of Intercepting Chamber. The intercepting chamber [37] is usually required to be placed on the owner's land, but as near the public sewer as possible, when one exists, or near the cesspool. In some town districts where houses are built up to the edge of the footway they are permitted in the public footway. In most cases at least one other inspection chamber is necessary, placed close to the most distant point to which the drain requires to be carried.

In the town-house plan [35] the house drains and the stable drains have in each case only the intercepting chamber and one o her. In the country-house plan [36], in which the rainwater drains and soil-drains are separated, many chambers are required, due partly to the large number of branches, partly to the changes of direction. The rainwater drains are given a smaller fall than the soil-drains, which is permissible as they have not to convey solid matter. Details of some of the chambers are given, indicating the method of combining the various fittings described under different conditions [37–40].

Continued

OBJECT DRAWING & PRACTICAL GEOMETRY

Objects on Same Principle as Cone and Cylinder. Triangular Prism. Square, Hexagonal and Octagonal Pyramids. Regular Polygons

By WILLIAM R. COPE

BY this time the student ought to have made such progress in drawing rectangular, conical, or cylindrical objects to be found among household utensils, etc.—such, for instance, as **155-160**—as to enable him to draw from much larger objects. It will help him if we discuss certain principles underlying the drawing of the triangular prism, square and polygonal pyramids.

Several different views are shown in **161** to **166** of a prism which has an equilateral triangle at each end. The student should obtain one or two such prisms, or make them out of bits of cardboard, fastened at the edges by means of tape or paper. A convenient size would be about 12 in. or 15 in. long, and edges of the triangular ends about 7 in. or 8 in. Place the prisms in such positions as indicated in **161** to **166**, and study *the apparent changes* in the form of the equilateral triangle, the foreshortening, in some views, of the long edges, and the direction of the apparent convergence of certain parallel edges. It is of little use to examine only the representations given in **161-166**; the student *must train his eye to see correctly* the many apparent forms which an object takes in various positions.

It will be seen that when the prism is lying flat down on one of its oblong faces the apex A (although really vertically over the *real* centre D of the base BC) is only apparently so when the student is directly opposite the end, as in **162**. In **161**, **163**, and **165**, the apex A is apparently vertically over the point D, which is not the *apparent* centre of the base BC, for the nearer *real* half CD in **161** and **163** is apparently slightly longer than the further *real* half BD, and in **165** BD is greater than DC. In **166** the apex A is vertically under the point D, as the prism is supposed to be resting on an edge, with its upper oblong surface parallel to the ground. Beginners often make an incorrect drawing like that in **167**, because they do not see the correct apparent position of the apex A with reference to the base BC. Of course, when the object is tilted, as in **161** and **165** the apex A does not necessarily appear vertically above the point D of the base BC; when the prism is in such positions the apex may appear to be in an infinite number of places not vertically over D; and to determine these relative positions careful observation of the object must be made. It should also be noticed how varied are the *apparent* lengths of the edges of the equilateral triangle, and of the long edges of the prism. In **163** the student should observe that the base BC of the further end is apparently slightly longer than BC of the nearer end; this is only another example of what was mentioned concerning the further end of the cylinder [see **152**]. Great attention should be given to the *direction* of apparently converging edges, although no errors should be made if the student remembers that receding parallel edges always appear to converge in the direction they go *from* him, whether upwards or downwards from him, or right and left away from him.

The Square and Other Pyramids. We will next examine the square pyramid, of which several correct representations are given in **168-175**; but **176** is incorrect, and shows a very common error made by beginners, who forget, or do not observe, that when the object is standing on its base, the axis AB of the pyramid ought to be *vertical*, and therefore also the apex A *vertically* over the centre B of the base as in **168**, **169**, and **175**. The triangular faces of the pyramid vary infinitely in their apparent forms, especially when the object is lying down on a triangular face, or when tilted as in **170-174**; and to obtain a true drawing the student must exercise his perceptive powers most carefully. In **175** we have a view of the pyramid with its axis vertical, and the object above the eye level; this shows how a spire or turret might appear on a building. Some spires and turrets are similar in construction to a hexagonal or octagonal pyramid, as shown in **177** and **178**, which are all representations of vertical positions of these pyramids, **177** and **181** being the appearance when below the eye level, **178** when the base is just on the eye level, and **179**, **180**, and **182** when above the level of the eye. In all of these (**177-182**) it will be seen that the axis AB and the apex A are again vertically above the centre B of the base. The position of this centre may be easily found by drawing diagonal lines, as indicated by dotted lines on the bases of **177-182**.

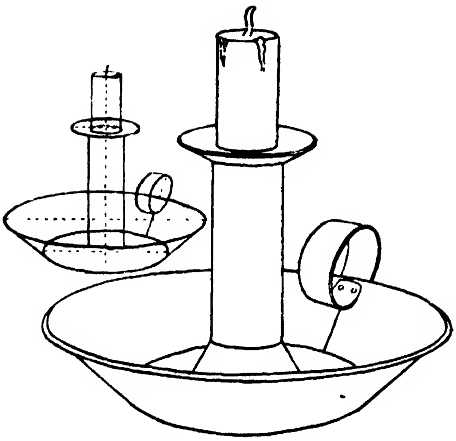
The student should now be prepared to make studies of objects such as **183-185**.

PRACTICAL GEOMETRY

Regular Polygons. There are general and special methods of constructing these polygons. The general methods, as in **187**, **188**, and **193-195**, apply equally to all polygons, but in particular polygons the special method is sometimes shorter and more accurate, as in **189-191**, and **196-198**. Remember the following important facts concerning *regular* polygons:

i. Lines which bisect the angles of regular polygons meet in one point, which is the centre of the figure, and they divide the polygon into a number of equal triangles. In the hexagon these are equilateral [**189**], but in all other regular polygons they are isosceles [**191-192**].

ii. The centre of the polygon is the same



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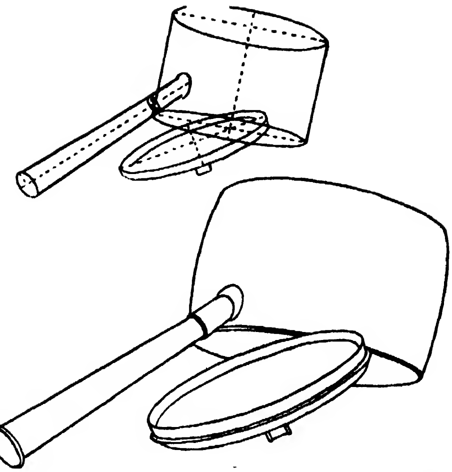

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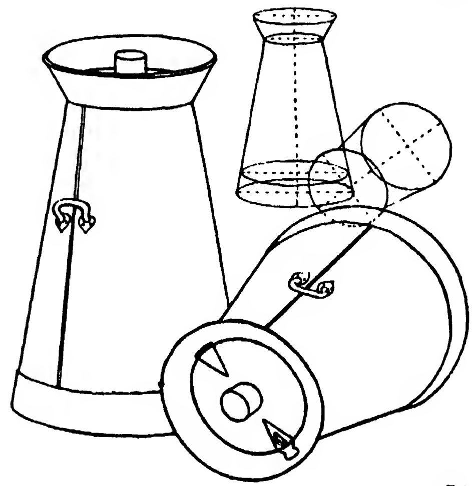

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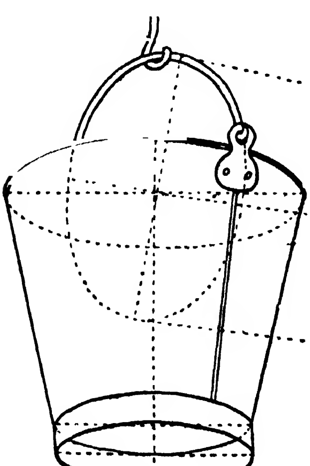

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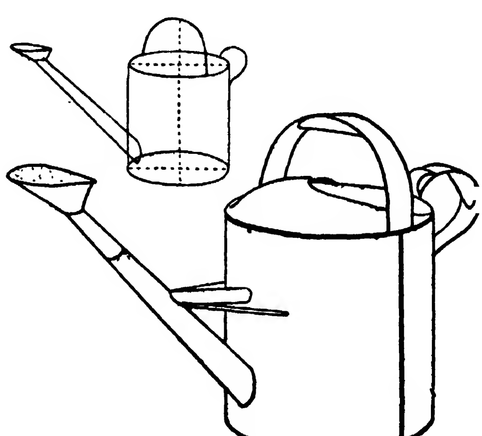
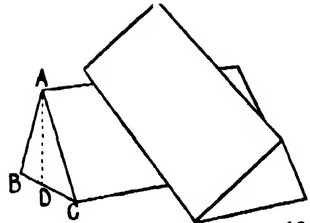


160

OBJECTS DRAWN ON SAME PRINCIPLE AS CONE AND CYLINDER



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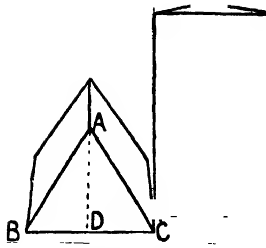

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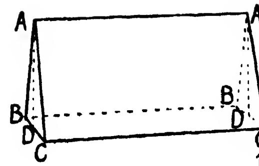

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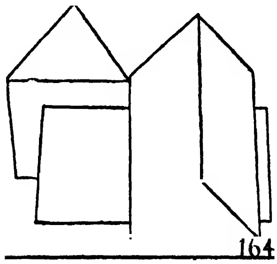

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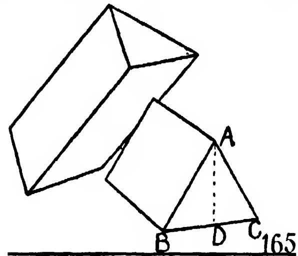

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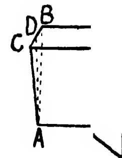
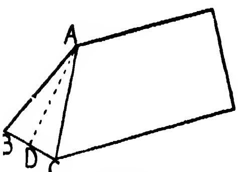
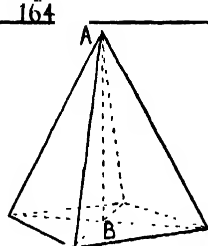




WRONG 167



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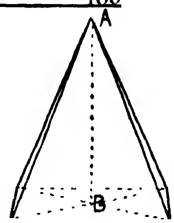

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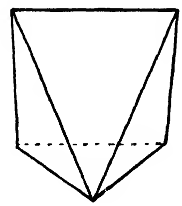

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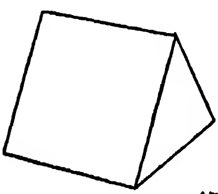

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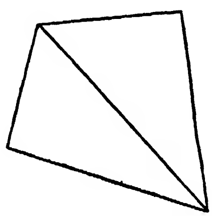

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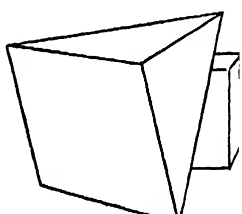

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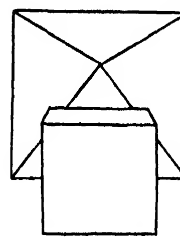

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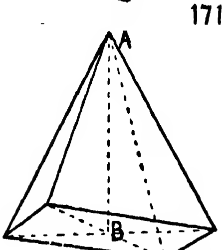

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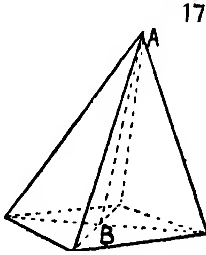
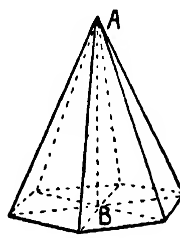


WRONG 176



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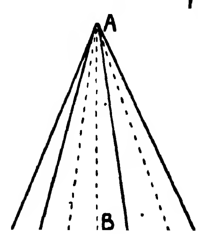

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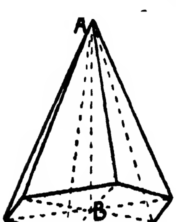

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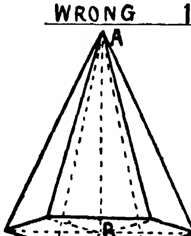

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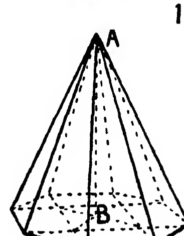

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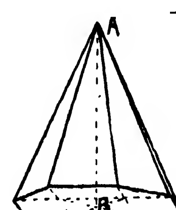
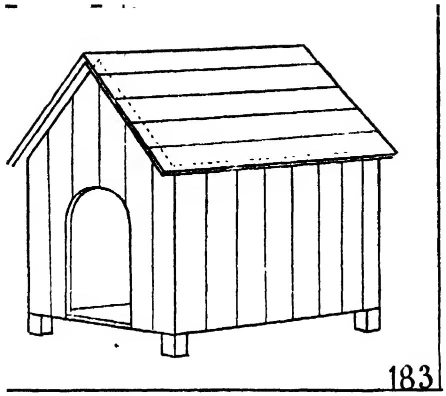


182

THE TRIANGULAR PRISM: SQUARE, HEXAGONAL, AND OCTAGONAL PYRAMIDS



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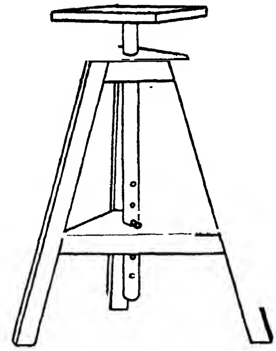

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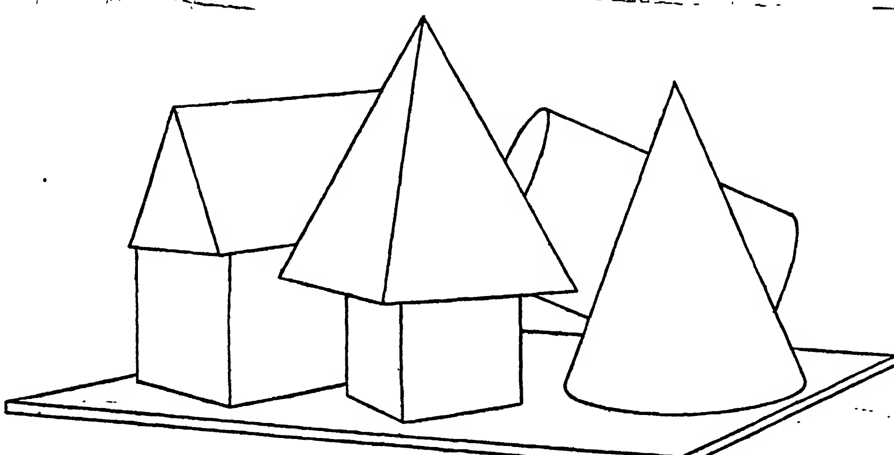
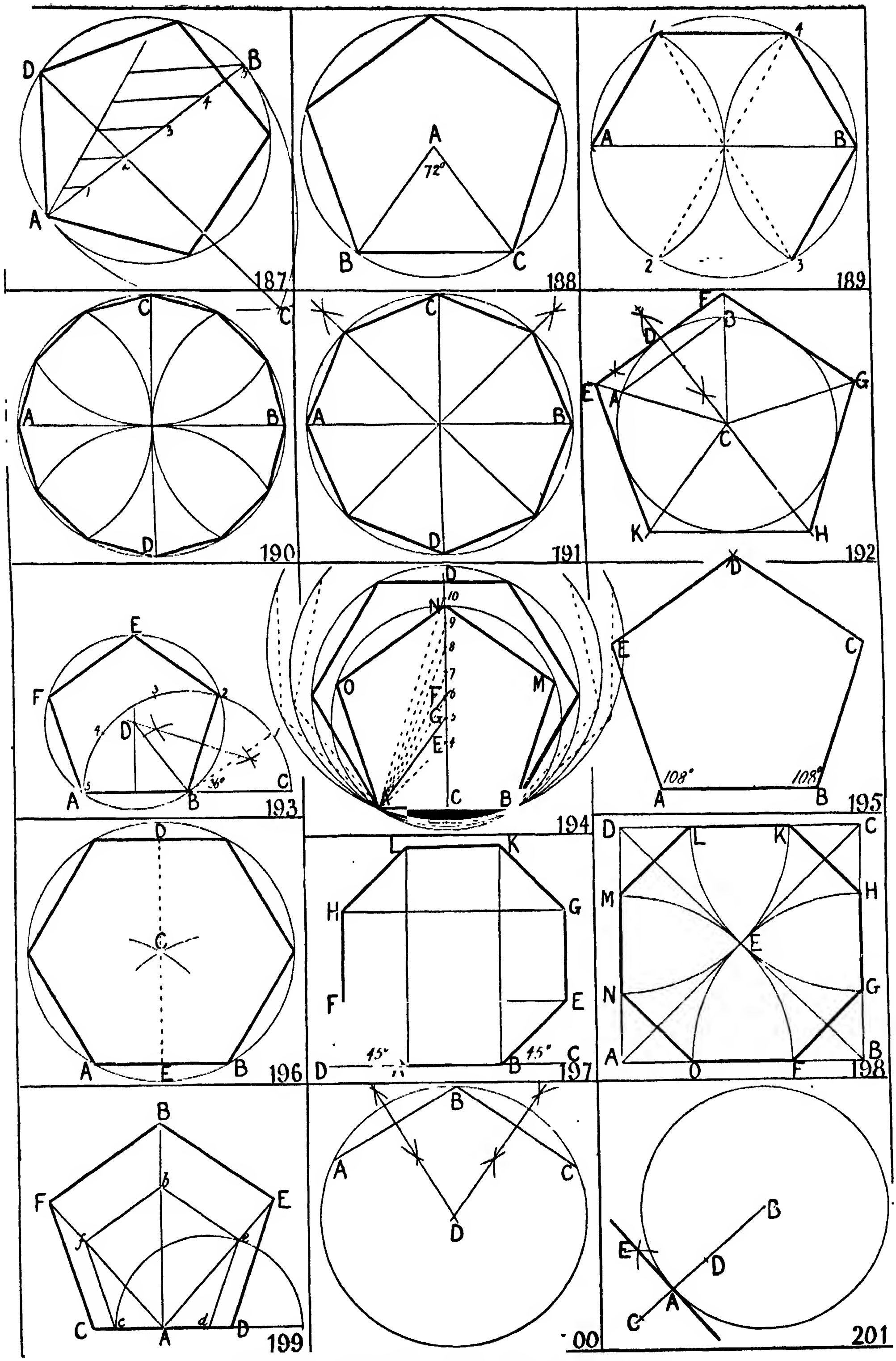


186

OBJECTS DRAWN ON THE SAME PRINCIPLES AS THE TRIANGULAR PRISM



PRACTICAL GEOMETRY. REGULAR POLYGONS, ETC.

as that of the circle to which the sides of the polygon are tangent (the *inscribed* circle) and also of the *circumscribed* circle which passes through the angular points [see **187–194**].

iii. The sum of all the interior angles of a regular polygon plus four right angles is equal to twice as many right angles as the figure has sides. [Euc. I. 32.] This affords a ready method of constructing any regular polygon by means of the protractor, as in **195**, when the side is given—a fact made use of in surveying.

187. In a Given Circle to Inscribe any Regular Polygon (Approximate Method). Draw the diameter AB and divide it into the same number of equal parts as the figure has sides (say five). With A and B as centres, and AB as radius, make arcs intersecting at C. From C draw CD, *always through the second division on* AB, cutting the circle in D. Join AD, which is one side of the pentagon required. Set off AD round circle and join points as shown.

188. Another Method. Draw any radius AB. At the centre A make an angle with AB equal to 360° divided by the number of sides of the regular polygon required, say a pentagon. Thus, $360° \div 5 = 72°$. Therefore, make the angle $BAC = 72°$. Join BC, which is one side of the pentagon. Set off BC round the circle, and join the points as shown.

189. To Inscribe a Regular Hexagon in a Given Circle (Special Method). Draw any diameter AB. With centres A and B, and radius equal to that of the circle, cut the circle in 1, 2, 3 and 4. Join the points as shown.

190. To Inscribe a Regular Duodecagon in a Given Circle (Special Method). Draw two diameters AB and CD perpendicular to each other. With centres A, B, C, and D, and radius equal to that of the circle, describe arcs cutting the circumference of the circle. Join the twelve points as shown.

191 To Inscribe a Regular Octagon in a Given Circle (Special Method). Draw two diameters AB and CD as in **190**. Bisect each quadrant thus formed, cutting the circumference as shown. Join the eight points thus obtained.

192. To Describe any Regular Polygon About a Given Circle (General Method). Divide the circumference into as many equal parts as the figure is to have sides (say, five for a pentagon). From the centre C draw lines through each point. Draw AB, one of the sides of the inscribed pentagon. Bisect AB by the perpendicular CD, cutting the circumference in D. Through D draw the tangent EF parallel to AB, cutting CE in E, and CF in F. Make CG, CH, and CK each equal to CE or CF. Join F, G, H, K and E as shown.

193. On a Given Line AB to Construct any Regular Polygon (General Method). Produce AB, and with centre B and radius BA describe a semi-circle, and divide it into the same number of equal parts as the figure has sides (say five). Join B with 2. Bisect AB and $B2$ by lines intersecting at D. With D as centre and radius DA or DB, or $D2$, describe a circle. Set off AF and FE each equal to AB. Join the points thus obtained.

Note. In this construction great care is required in dividing the semi-circle correctly, which may be done with the protractor. As there are 180° in a semi-circle, divide 180° by the number of sides the polygon will have; thus, $180° \div 5 = 36°$. Then make the angle $CB1$ equal to 36°, and mark off $C1$ round the semi-circle as shown. The semi-circle may be divided into *four* equal parts with the 45° set square, and into *three* equal parts with the 60° set square.

194. Another General Method. Bisect AB by the perpendicular CD. Make CE equal to AC or BC. With centre B and radius BA describe an arc cutting CD in E. E and F are respectively the centres of circles belonging to the square and hexagon. Bisect EF in G. With centre G and GA or GB as radius, describe a circle, and set off AB round it. Join the points, and $ABMNO$ is the pentagon required. By making 6 7, 7 8, 8 9, etc., each equal to 4 5 or 5 6, we obtain centres for the heptagon, octagon, etc., as shown.

195. Another General Method, by Using the Protractor. The number of degrees in each angle of a regular polygon may be found as follows: *From twice as many right angles as the figure has sides, subtract four right angles, and divide the remainder by the number of angles in the figure.* [Paragraph iii.] Suppose a regular pentagon be required. As it has five sides, from *ten* right angles deduct four, and the remainder is six right angles. Then $(90° \times 6) \div 5 = 540° \div 5 = 108°$. At A and B make angles of 108°. Make AE and BC each equal to AB. With E and C as centres and AB as radius make arcs intersecting at D. Join the points as shown. For a nonagon the angle would be found thus: From eighteen right angles deduct four, leaving fourteen right angles. Then $(90° \times 14) \div 9 = 1260° \div 9 = 140°$.

198. To Inscribe an Octagon in a Given Square $ABCD$. Draw the diagonals AC and BD. With centres A, B, C and D, and radius AE (half the diagonal), describe arcs cutting the sides of the square in F, G, H, K, L, M, N and O. Join FG, HK, LM, and NO. Then $FGHKLMNO$ is the required octagon.

199. To Construct any Regular Polygon, having the Diameter AB Given. Through A draw CD perpendicular to AB. Take any convenient distance Ac, and make Ad equal to it. Upon cd construct, say, a regular pentagon $cdebf$. From A draw lines through e and f. From B draw BE and BF respectively, parallel to be and bf. And from E and F draw ED and FC parallel to ed and fc. Then $CDEBF$ is the required pentagon.

It should be noted that the diameter divides the polygon into two equal parts. In a polygon with an *equal* number of sides, the diameter passes through the centre, and is terminated at the middle points of two opposite and parallel sides, as DE in **196**; but in a polygon with an *odd* number of sides, it passes through the centre from one angle to the middle point of the opposite side, as AB in **199**.

Continued

GERMAN—FRENCH—LATIN—ENGLISH

German by P. G. Konody and Dr. Osten; French by Louis A. Barbé, B.A.; Latin and English by G. K. Hibbert, M.A.

Continued from page 608

GERMAN

Continued from page 254

By P. G. Konody and Dr. Osten

The Article.

I. The DEFINITE ARTICLE is denoted in German by der for the masculine gender (*m.*), die for the feminine (*f.*), and das for the neuter (*n.*). This grammatical gender is, however, quite arbitrary and not always associated with the sex of persons, or with its absence in the case of objects It is therefore *absolutely necessary*, when committing a particular noun to memory, to connect it inseparably with its definite article.

The definite article is often used in German when it is omitted in English, with collective and abstract nouns, names of streets, mountains, metals, seasons, months, days; before proper names preceded by adjectives.

The INDEFINITE ARTICLE is expressed by ein for masculine and neuter, and eine for feminine substantives.

II. All substantives and nouns used substantively are written in German with capitals; all other words with small letters, except those which begin a new sentence or a quotation after a colon.

Examples of Gender:

Masculine:		*Feminine:*		*Neuter:*	
der (ein) Mann;	the (a) man.	die (eine) Frau;	the (a) woman.	das (ein) Kind;	the (a) child
der (ein) Vater;	the (a) father.	die (eine) Mutter;	the (a) mother.	das (ein) Mädchen;	the (a) girl.
der (ein) Fisch;	the (a) fish.	die (eine) Schlange;	the (a) serpent.	das (ein) Wiesel;	the (a) weasel.
der (ein) Mund;	the (a) mouth.	die (eine) Hand;	the (a) hand.	das (ein) Ohr;	the (an) ear.
der (ein) Rock;	the (a) coat.	die (eine) Weste;	the (a) waistcoat.	das (ein) Hemd;	the (a) shirt.
der (ein) Tisch;	the (a) table.	die (eine) Bank;	the (a) bench.	das (ein) Bett;	the (a) bed.
der (ein) Wald;	the (a) forest.	die (eine) Wiese;	the (a) meadow.	das (ein) Feld;	the (a) field.
der (ein) Mond;	the (a) moon.	die (eine) Sonne;	the (a) sun.	das (ein) Licht;	the (a) light.
der (ein) Bach;	the (a) brook.	die (eine) Welle;	the (a) wave.	das (ein) Meer;	the (a) sea.
der (ein) Tag;	the (a) day.	die (eine) Woche;	the (a) week.	das (ein) Jahr;	the (a) year.

Personal Pronouns.

III. The personal pronouns are:

ich: I.	wir: we.
du: thou.	ihr: you.
er, sie, es: he, she, it.	sie: they.

NOTES: 1. The second person singular, which in English is only used in biblical parlance, is much more frequently employed in German, where it is the usual form of address in the family circle, or among intimate friends. The general or polite form of address is the third person plural: Sie haben (you have), Sie sind (you are) etc. To distinguish this form of address from the grammatical form, the word Sie, when used for "you," has a capital letter, whilst sie for "they" has not. The capital is, of course, retained in the declension. The first person singular „ich" only has a capital at the beginning of a sentence.

2. There are, in German literature, two other forms of address, besides the du and Sie. One of them corresponds to the English "you" (second person plural)—Ihr seid, Ihr habt—and is used in the classic drama. The other—er ist, er hat (third person singular)—is an antiquated and rather contemptuous form of addressing subordinates. Both these forms are not in use at the present time, but they will be frequently found in literature.

3. In letters Du (thou) and Ihr (you) are, for reasons of courtesy, always written with capitals.

The Verb.

IV. 1. All verbs in German terminate in en or n. Thus, the verb arbeiten (to work) is formed of the stem arbeit and the suffix -en; rauchen (to smoke), of rauch-en; geben (to give), of geb-en.

2. THE AUXILIARY VERBS OF TENSES are: sein, to be; haben, to have; and werden, to become. Note the omission of the preposition in the infinitive. These auxiliary verbs are used as in English, either independently, or for the formation of compound tenses of other verbs Their conjugation, which is irregular, is to be found in the following tables.

TABLE V.

Conjugation of the Auxiliary Verbs.

INFINITIVE.

Present:	sein	— to be.	haben	— to have.	werden	— to become.
Past:	gewesen sein	— to have been.	gehabt haben	— to have had.	geworden sein	— to have become.

PARTICIPLE.

Present:	seiend	— being.	habend	— having.	werdend	— becoming.
Past:	gewesen	— been.	gehabt	— had.	geworden	— become.

Present.

INDICATIVE.

S. 1.	ich bin	— I am.	ich habe	— I have.	ich werde	— I become.
2.	du bist	— thou art.	du hast	— thou hast.	du wirst	— thou becomest.
3.	er* ist	— he* is.	er hat	— he has.	er wird	— he becomes.
P. 1.	wir sind	— we are.	wir haben	— we have.	wir werden	— we become.
2.	ihr seid	— you are.	ihr habet	— you have.	ihr werdet	— you become.
3.	sie sind	— they are.	sie haben	— they have.	sie werden	— they become.

CONJUNCTIVE (*Subjunctive*).

S. 1.	ich sei	— I be.	ich habe	— I have.	ich werde	— I become.
2.	du sei(e)st	— thou be.	du habest	— thou have.	du werdest	— thou become.
3.	er sei	— he be.	er habe	— he have.	er werde	— he become.
P. 1.	wir seien	— we be.	wir haben	— we have.	wir werden	— we become.
2.	ihr sei(e)t	— you be.	ihr habet	— you have.	ihr werdet	— you become.
3.	sie seien	— they be.	sie haben	— they have.	sie werden	— they become.

Imperfect†.

INDICATIVE.

S. 1.	ich war	— I was	ich hatte	— I had.	ich ward (wurde)	— I became
2.	du warst	— thou wast	du hattest	— thou hadst.	du wardst (wurdest)	— thou becamest
3.	er war	— he was	er hatte	— he had.	er ward (wurde)	— he became.
P. 1.	wir waren	— we were	wir hatten	— we had.	wir wurden	— we became.
2.	ihr waret	— you were	ihr hattet	— you had.	ihr wurdet	— you became.
3.	sie waren	— they were	sie hatten	— they had.	sie wurden	— they became.

CONJUNCTIVE (*Subjunctive*).

S. 1.	ich wäre	— I were.	ich hätte	— I had	ich würde	— I became.
2.	du wärest	— thou were.	du hättest	— thou hadst.	du würdest	— thou becamest.
3.	er wäre	— he were.	er hätte	— he had.	er würde	— he became.
P. 1.	wir wären	— we were.	wir hätten	— we had.	wir würden	— we became.
2.	ihr wäret	— you were.	ihr hättet	— you had.	ihr würdet	— you became.
3.	sie wären	— they were.	sie hätten	— they had.	sie würden	— they became.

Perfect.

INDICATIVE.

S. 1.	ich bin gewesen	— I have been.	ich habe gehabt	— I have had.	ich bin geworden	— I have become.
2.	du bist gewesen	— thou hast been.	du hast gehabt	— thou hast had.	du bist geworden	— thou hast become.
3.	er ist gewesen	— he has been.	er hat gehabt	— he has had.	er ist geworden	— he has become.
P. 1.	wir sind gewesen	— we have been.	wir haben gehabt	— we have had.	wir sind geworden	— we have become.
2.	ihr seid gewesen	— you have been.	ihr habt gehabt	— you have had.	ihr seid geworden	— you have become.
3.	sie sind gewesen	— they have been.	sie haben gehabt	— they have had.	sie sind geworden	— they have become.

CONJUNCTIVE (*Subjunctive*).

S. 1.	ich sei gewesen	— I have been.	ich habe gehabt	— I have had.	ich sei geworden	— I have become.
2.	du sei(e)st gewesen	— thou have been.	du habest gehabt	— thou have had.	du sei(e)st geworden	— thou have become.
3.	er sei gewesen	— he have been.	er habe gehabt	— he have had.	er sei geworden	— he have become.
P. 1.	wir seien gewesen	— we have been.	wir haben gehabt	— we have had.	wir seien geworden	— we have become.
2.	ihr sei(e)t gewesen	— you have been.	ihr habet gehabt	— you have had.	ihr sei(e)t geworden	— you have become.
3.	sie seien gewesen	— they have been.	sie haben gehabt	— they have had.	sie seien geworden	— they have become.

* The third person stands of course for all three genders: er, sie, es: he, she, it.

† The IMPERFECT and the PLUPERFECT of the conjunctive can be circumscribed by the I. and II. Conditional.

TABLE V.—*Continued.*

Pluperfect.*

INDICATIVE.

		gewesen	been.	gehabt	had.	geworden	become.
S.	1.	ich war	—I had	ich hatte	—I had	ich war	—I had
	2.	du warst	—thou hadst	du hattest	—thou hadst	du warst	—thou hadst
	3.	er war	—he had	er hatte	—he had	er war	—he had
P.	1.	wir waren	—we had	wir hatten	—we had	wir waren	—we had
	2.	ihr waret	—you had	ihr hattet	—you had	ihr waret	—you had
	3.	sie waren	—they had	sie hatten	—they had	sie waren	—they had

CONJUNCTIVE (*Subjunctive*).

		gewesen	been.	gehabt	had.	geworden	become.
S.	1.	ich wäre	—I had	ich hätte	—I had	ich wäre	—I had
	2.	du wärest	—thou hadst	du hättest	—thou hadst	du wärest	—thou hadst
	3.	er wäre	—he had	er hätte	—he had	er wäre	—he had
P	1.	wir wären	—we had	wir hätten	—we had	wir wären	—we had
	2.	ihr wäret	—you had	ihr hättet	—you had	ihr wäret	—you had
	3.	sie wären	—they had	sie hätten	—they had	sie wären	—they had

First Future.

INDICATIVE. — CONJUNCTIVE (*Subjunctive*).

S.	1.	ich werde		I shall		ich werde		I shall	
	2.	du wirst	sein,	thou wilt	be.	du werdest	sein,	thou wilt	be.
	3.	er wird		he will		er werde		he will	
P.	1.	wir werden	haben,	we shall	have.	wir werden	haben,	we shall	have.
	2.	ihr werdet	werden,	you will	become.	ihr werdet	werden,	you will	become
	3.	sie werden		they will		sie werden		they will	

Second Future.

S.	1.	ich werde	gewesen sein,	I shall	have been.	ich werde	gewesen sein,	I shall	have been.
	2.	du wirst		thou wilt		du werdest		thou wilt	
	3.	er wird	gehabt haben,	he will	have had.	er werde	gehabt haben,	he will	have had.
P.	1.	wir werden		we shall		wir werden		we shall	
	2.	ihr werdet	geworden sein,	you will	have become.	ihr werdet	geworden sein,	you will	have become.
	3.	sie werden		they will		sie werden		they will	

I. CONDITIONAL (*of the Imperfect*). — II. CONDITIONAL (*of the Perfect*).

S.	1.	ich würde	sein,	I should	be.	ich würde	gewesen sein,	I should	have been.
	2.	du würdest	haben,	thou wouldst	have.	du würdest	gehabt haben,	thou wouldst	have had.
	3.	er würde	werden,	he would	become.	er würde	geworden sein,	he would	have become.
P.	1.	wir würden		we should		wir würden		we should	
	2.	ihr würdet		you would		ihr würdet		you would	
	3.	sie würden		they would		sie würden		they would	

The I. Conditional may be used alternately with the IMPERFECT of the CONJUNCTIVE and the II. Conditional alternating with the PLUPERFECT of the CONJUNCTIVE.

IMPERATIVE.

Singular:	sei! —	be!	habe! —	have!	werde! —	become!
Plural:	seid! —	„	habet! —	„	werdet! —	„

The student is advised to learn first the tenses in the Indicative, and to reserve the study of the Conjunctive until he is further advanced in his knowledge of German.

EXAMPLES with the present tense of sein (see Table V.).

Ich	bin	ein	Mann,	du	bist	der	Vater,
I	am	a	man	thou	art	the	father
er	ist	ein	Sohn,	sie	ist	eine	Frau,
he	is	a	son	she	is	a	woman
es ist ein Kind,				wir sind hier,		ihr seid dort,	
it is a child				we are here		you are there	
Sie sind gut,				sie sind gut.			
you are good				they are good.			

Declension.

V. 1. The German substantives have three systems of declension: the *strong*, the *weak*, and the *mixed*.

2. In the declension the substantives generally take suffixes with or without modification of the root vowels. For the sake of euphony certain consonants are sometimes doubled and vowels omitted.

* The IMPERFECT and the PLUPERFECT of the conjunctive can be circumscribed by the I. and II. Conditional.

TABLE VI.—EXAMPLES OF THE STRONG DECLENSION.

	1. MASCULINE GENDER *Genit. suffix* -es	2. MASCULINE GENDER *Genit. suffix* -s	3. FEMININE GENDER *unaltered singular*	4. NEUTER GENDER *Genit. suffix* -es	5. NEUTER GENDER *Genit. suffix* -s	6. MASCULINE GENDER *Genit. suffix* -es	7. FEMININE GENDER *unaltered singular*	8. MASCULINE GENDER *Genit. suffix* -s	9. MASCULINE GENDER *Genit. suffix* -s
S. 1.	der Mann the man	der Lehrer the teacher	die Mutter the mother	das Kind the child	das Mädchen the girl	der Tisch the table	die Maus the mouse	der Garten the garden	der Lord the lord
„ 2.	des Mann-es of the man	des Lehrer-s of the teacher	der Mutter of the mother	des Kind-es of the child	des Mädchen-s of the girl	des Tisch-es of the table	der Maus of the mouse	des Garten-s of the garden	des Lord-s of the lord
„ 3.	dem Mann-e to the man	dem Lehrer to the teacher	der Mutter to the mother	dem Kind-e to the child	dem Mädchen to the girl	dem Tisch-e to the table	der Maus to the mouse	dem Garten to the garden	dem Lord to the lord
„ 4.	den Mann the man	den Lehrer the teacher	die Mutter the mother	das Kind the child	das Mädchen the girl	den Tisch the table	die Maus the mouse	den Garten the garden	den Lord the lord
	Modification of the Vowel and Suffix -er	*1. Singular and 1. Plural alike.*	*Modification of the Vowel.*	*Suffix* -er	*Singular and Plural alike. NO Dative Inflection.*	*Suffix* -e	*Suffix* -e *and Modification of the Vowel.*	*Modification of the Vowel. NO Dative Inflection.*	*Suffix* -s
Pl. 1.	die Männ-er the men	die Lehrer the teachers	die Mütter the mothers	die Kind-er the children	die Mädchen the girls	die Tisch-e the tables	die Mäus-e the mice	die Gärten the gardens	die Lord-s the lords
„ 2.	der Männ-er to the men	der Lehrer of the teachers	der Mütter of the mothers	der Kind-er of the children	der Mädchen of the girls	der Tisch-e of the tables	der Mäus-e of the mice	der Gärten of the gardens	der Lord-s of the lords
„ 3.	den Männ-ern of the men	den Lehrer-n to the teachers	den Mütter-n to the mothers	den Kind-ern to the children	den Mädchen to the girls	den Tisch-en to the tables	den Mäus-en to the mice	den Gärten to the gardens	den Lord-s to the lords
„ 4.	die Männ-er the men	die Lehrer the teachers	die Mütter the mothers	die Kind-er the children	die Mädchen the girls	die Tisch-e the tables	die Mäus-e the mice	die Gärten the gardens	die Lord-s the lords

3. DECLENSION OF THE DEFINITE ARTICLE.

Singular.

Nom.:	der (*m.*)	die (*f.*)	das (*n.*)	the
Gen.:	des	der	des	of the
Dat.:	dem	der	dem	to the
Acc.:	den	die	das	the

Plural (alike for all three genders).

Nom.:	die	the
Gen.:	der	of the
Dat.:	den	to the
Acc.:	die	the

4. DECLENSION OF THE INDEFINITE ARTICLE.

Nom.:	ein (*m.*)	ein-e (*f.*)	ein (*n.*)	a (an)
Gen.:	ein-es	ein-er	ein-es	of a (an)
Dat.:	ein-em	ein-er	ein-em	to a (an)
Acc.:	ein-en	ein-e	ein	a (an)

It will be seen that both articles have in many cases the same inflections, and that several cases show no changes (Nom. and Acc. *f.* and *n.* and the Gen. and Dat. *f.* The indefinite article has no plural).

DECLENSION OF NOUNS.

VI. 1. *Masculine* and *neuter substantives* in the strong declension

(*a*) add in the *Gen. sing.* -es or -s,
(*b*) cast off in the *Dat. sing.* the -s of the suffix acquired in the *Genitive,*
(*c*) retain in the *Acc.* the form of the *Nominative.*

2. *Feminine substantives* remain unchanged in the *Singular* (see Table VI., 3 and 7).

3. In the *Plural* of the strong declension the substantives

(*a*) retain in the *Nom.* the form of the *Nom. sing.* (see Table VI., 2 and 5); or
(*b*) add the suffixes -e, -er or -s, with or without modification of the root vowels a, o, u, au into ä, ö, ü, äu,
(*c*) retain these forms in the *Gen.*,
(*d*) retain in the *Acc.* the form of the *Nom.* (See Table VI., 1, 3, 4, 6, 7, 8, 9.)
(*e*) add in the *Dat.* the further suffix -n, (See Table VI., 1, 3, 4, 6, 7.)

Group (*a*) remains unchanged in the *Nom.*, *Gen.*, and *Acc.*, and only takes the -n in the *Dat.* unless the words belong to the following exceptions:

4. The *Suffix* -n is not added in the *Dat. Plur.* to nouns which have the *Nom. Plur.* terminating in -n (Table VI., 5 and 8). In nouns which terminate in -s in the *Nom. Plur.* (mostly of foreign derivation: die Lords, die Jockeys, die Chefs etc.), the *Dat.* also remains unchanged (Table VI., 9).

EXAMINATION PAPER II.

1. Which are the definite and the indefinite articles for the three genders in German, and which of them coincide?
2. When is the definite article used in German and omitted in English?
3. Which personal pronoun is always written with a capital, and when are other pronouns written with capitals or with small initials?
4. How many forms of personal address are employed in German, and which is the familiar form?
5. How is the Infinitive of the verb formed in German?
6. How do you recognise the strong declension of masculines and neuters in the singular, and of all three genders in the plural?
7. Are there any parallels in the declension of the definite and the indefinite articles?
8. What is the characteristic feature of the singular in the strong declension of feminines?
9. Which class of substantives takes the suffix -s in the strong Plural?
10. Are there any exceptions to the use of the suffix -n for denoting the Dative Plural of the strong declension?
11. What is the characteristic trait of the Dative Sing. in the strong declension?
12. Is there an auxiliary verb of tense in German which has to be replaced in English by an ordinary verb?

For Examples see the preceding paragraphs.

EXERCISE I.

Insert in the blank spaces

(*a*) THE DEFINITE ARTICLE.

.... Mann (*m.*), ... Frau (*f.*), ... Kind (*n*),
the man (husband); the woman (wife); the child:
.... Bank (*f.*), ... Hemd (*n.*), ... Mond (*m.*),
the bank; the shirt; the moon;
.... Rock (*m.*), ... Hand (*f.*),
the coat; the hand;
.... Mann (*m.*) .... Frau (*f.*), ... Frau (*f.*)
the husband of the woman; the wife
... Mann-es (*m.*), ... Vater (*m.*) ... Kind-es (*n.*),
of the man; the father of the child;
.... Welle (*f.*) .... Meer-es (*n.*), ... Kind (*n.*) ....
the wave of the sea; the child of the
Frau (*f.*) und .... Mann-es [*m.*), ... Licht (*n.*)
woman and the man; the light
.... Mond-es (*m.*) und .... Sonne (*f*).
of the moon and of the sun.

(*b*) THE INDEFINITE ARTICLE.

Gib* .... Kinde (*n.*) .... Frau (*f.*) .... Apfel (*m.*),
give to the child of the woman an apple;
gib .... Frau (*f.*) .... Weste (*f.*) und .... Rock (*m.*),
give to the woman a waistcoat and a coat;
ich gab* .... Hemd (*n.*) .... Manne (*m.*) und ....
I gave the shirt to a man and a
Weste (*f.*) .... Frau (*f.*) für .... Mann (*m.*).
waistcoat to the woman for the man.

* Gib is the *imperative singular,* and ich gab the *imperfect,* of geb-en to give.

EXERCISE II.

Insert in the blank spaces:

(*a*) THE PERSONAL PRONOUNS AND THE ARTICLES.

[Mind the Initials! See **II.** and **III.**]

..... bin ..... Vater (*m.*) ..... Kind=es (*n.*)
I am a father of a child;

.... ist .... Mutter (*f.*).
she is a mother.

.... bist .... Mann (*m.*), ... sind .... Freund (*m.*).
Thou art the man; You are a friend.

.. ist ... Kind (*n.*) ... Frau (*f.*) und ... Mann=es (*m.*).
It is a child of the woman and of the man

.... seid Mann und Frau.
You are husband and wife.

(*b*) THE AUXILIARY VERB sein (to be) in the present tense and THE ARTICLES.

Ich .... Freund .... Vaters. Du ....
I am a friend of the father. Thou art the

Frau .... Mann=es und .... Mutter .... Mädchen=s.
wife of the man and the mother of a girl.

Er ... hier, sie ... dort, es .... Kind ....
He is here; she is there; it is a child of a

Freund=es, wir .... Männ=er, ihr .... Mütter und
friend; we are men; you are mothers and

sie .... Kinder. Sie .... Freund .... Mutter
they are children. You are a friend of the mother

und er .... Freund .... Mädchen=s.
and he is a friend of the girl.

Continued

FRENCH

Continued from page .50

By Louis A. Barbé, B.A.

THE ARTICLE.

The Definite Article. 1. The definite article (*article défini*) has the forms *le, la, l', les,* all meaning *the.*

2. *Le* is used before masculine singular nouns, beginning with a consonant or aspirated *h,* as: *le livre* (the book), *le crayon* (the pencil), *le papier* (the paper), *le héros* (the hero), *le haut* (the top).

3. *La* is used before feminine singular nouns beginning with a vowel or silent *h,* as: *la plume* (the pen), *la table* (the table), *la règle* (the ruler), *la hauteur* (the height).

4. *L'* is used before all singular nouns, whether masculine or feminine, beginning with a vowel or silent *h,* as: *l'encrier,* m. (the inkstand), *l'homme,* m. (the man), *l'encre,* f. (the ink), *l'herbe,* f. (the grass).

5. *Les* is used before all plural nouns. These forms are used in the same way before adjectives preceding nouns.

6. "Of" is *de,* which also means "from"; but when joined with *le*—that is, before a masculine singular noun beginning with a consonant or aspirated *h*—the two words are contracted into *du* (of the): *le cahier,* the copybook; *du cahier,* of the copybook.

7. There is no contraction of the preposition *de* with the feminine form *la,* nor with the form *l',* thus: *la chaise,* the chair; *de la chaise,* of the chair; *l'homme, de l'homme; l'herbe, de l'herbe.*

8. "To" is *à,* but when joined with *le*—that is, before a masculine singular noun beginning with a consonant or aspirated *h*—the two words are contracted into *au: le buvard,* the blotting-book; *au buvard,* to the blotting-book.

9. There is no contraction with the feminine form *la,* nor with the form *l',* thus: *la grammaire,* the grammar; *à la grammaire,* to the grammar; *l'histoire,* the history or story; *à l'histoire,* to the story.

10. *De* and the plural form *les* always contract into *des; à* and the plural form *les* always contract into *aux.*

11. The definite article must be repeated before every noun, thus: the father and mother, *le père et la mère.*

12. To form the plural of nouns and adjectives *s* is added to the singular: *les pères, les mères, les enfants.*

13. There are only two genders in French—masculine and feminine.

14. There is no possessive case. It must always be rendered by "of the," *du, de la, de l',* or *des,* thus: the father's house, *la maison du père;* the children's mother, *la mère des enfants.*

15. The definite article is required in French, though not in English, before every noun that is used to designate a whole class. Thus in *les chiens sont des quadrupèdes,* dogs are quadrupeds, the article is used before *chiens* because the statement made is applicable to all dogs. Before *quadrupèdes* only a partitive article [see next column] is used, because dogs are only a division of the class quadrupeds.

The definite article is also required before abstract nouns, the names of arts, sciences, etc., and also before the names of materials: *la charité est une vertu,* charity is a virtue: *l'arithmétique est la science des nombres,* arithmetic is the science of numbers; *l'or est un métal,* gold is a metal.

The definite article is used before a single individual designating a whole class: *le fer est utile à l'homme,* iron is useful to man.

The Indefinite Article. 1. The indefinite article (*article indéfini*) is identical in form with the numeral "one," *un.* The feminine is formed, as in the case of adjectives, by adding mute *e* to the masculine: *un, une—un homme,* a man; *une femme,* a woman.

2. There is no contraction of *de* or *à* with *un, une;* but the *e* of *de* is elided before it: *d'un mur,* of a wall; *d'une maison,* of a house.

3. The indefinite article must be repeated before each noun to which it refers: a brother and a sister, *un frère et une sœur.*

4. As regards pronunciation, *un* has a nasal sound before a word beginning with a consonant or aspirated *h*. *Une* is never nasal. There is a difference of opinion as to the pronunciation of *un* before a vowel or mute h. Some hold that the *u* should be pronounced with its natural sound, and the *n* carried on to the next word, thus: *un ami* (a friend) becomes *u-nami*. This, however, has the disadvantage of making no difference between masculine and feminine—*e.g.*, *un aide* (a helper), and *une aide* (a help), have exactly the same sound. For this reason, other authorities give *u* the sound of *eu* (approximating the slurred sound of *e* in such a combination as "the boy"), and pronounce *un aide* as *ĕ-naid*, thus distinguishing it from *une aide*—*ü-n(e)aid*.

The Partitive Article. 1. When a noun is used to indicate only a part of that to which it is applicable, it is said to be taken "partitively." In English this idea is expressed by "some" and "any," which are, however, very frequently omitted: He drinks (some) water; we have bought (some) pens.

In French, when a noun is taken partitively, it is preceded by a form of the definite article, to which the name "partitive article" is then given.

2. The partitive article (*article partitif*) is *du*, *de la*, *de l'*, *des*. These forms are used in the same way as has already been explained in the case of the definite article, thus: *j'ai du papier*, I have some paper; *il a de la patience*, he has patience; *vous avez de l'encre*, you have some ink; *ils ont des crayons*, they have some pencils.

3. When a noun used partitively is the subject of a verb, it takes the partitive article: Friends—*i.e.*, some friends—have given it to me, *des amis me l'ont donné*.

4. Although, including the preposition *de*, the partitive article may be preceded by another preposition: *j'ai parlé à des amis*, I have spoken to some friends; *j'écris avec de l'encre*, I write with (some) ink.

5. When a noun taken partitively is preceded by an adjective, only *de* is used to express the partitive sense, thus: *j'ai de bons crayons*, I have some good pencils. This rule is frequently neglected in conversation, and it has been proposed to do away with it altogether.

6. When a noun taken partitively is the object of a negative verb, only *de* (which becomes *d'* before a vowel or mute *h*) is used with it: *je n'ai pas de papier*, I have no paper; *il n'a pas de patience*, he has no patience; *vous n'avez pas d'encre*, you have no ink; *ils n'ont pas de crayons*, they have no pencils.

7. When used negatively verbs are placed between *ne* and *pas*; *ne* becomes *n'* before a vowel or mute *h*: *je n'ai pas*, I have not.

8. When a noun taken partitively is preceded by *de* (of), neither the partitive article nor another *de* is used: I have need of (some) pencils, *j'ai besoin de crayons*.

9. When a noun taken partitively is not actually expressed, but only understood in a sentence—that is to say, when "some," "any" ("not any" = "none") occur alone in English—the pronoun *en* is used instead of the partitive article or of de. Its place is before the verb: I have some, *j'en ai*; we have not any, *nous n'en avons pas*.

10. The various ways in which the "partitive sense" may be expressed are the following:

(*a*) *J'ai du papier*, I have some paper.

(*b*) *J'ai de bons crayons*, I have some good pencils.

(*c*) *Vous n'avez pas de livres*, you have not any books.

(*d*) *Nous avons besoin de papier, d'encre, et de plumes*, we have need of paper, ink, and pens.

(*e*) *Il en a, elle n'en a pas*, he has some, she has none.

11. Subject to these rules, the "partitive sense" must *always* have something to indicate it before *every word taken partitively*.

Present Indicative of Avoir, To Have

Affirmatively—

j'ai, I have (*j'ĕy*).
tu as, thou hast (*tü ăh*).
il a, he (it) has (*il ăh*).
elle a, she (it) has.
nous avons, we have (*nōō-za-vong*).
vous avez, you have (*vōō-za-vĕy*).
ils ont, they (m.) have (*il-zong*).
elles ont, they (f.) have.

Negatively—

je n'ai pas, I have not.
tu n'as pas, thou hast not.
il n'a pas, he has not.
elle n'a pas, she has not.
nous n'avons pas, we have not.
vous n'avez pas, you have not.
ils n'ont pas, they (m.) have not.
elles n'ont pas, they (f.) have not.

Present Indicative of Être, To Be.

Affirmatively—

je suis, I am (*jĕ süēē*).
tu es, thou art (*tü ĕy*).
il est, he is (*il ĕy*).
elle est, she is.
nous sommes, we are (*sŏm*).
vous êtes, you are (*āte*).
ils sont, they (m.) are (*il song*).
elles sont, they (f.) are.

Negatively—

je ne suis pas, I am not.
tu n'es pas, thou art not.
il n'est pas, he is not.
elle n'est pas, she is not.
nous ne sommes pas, we are not.
vous n'êtes pas, you are not.
ils ne sont pas, they (m.) are not.
elles ne sont pas, they (f.) are not.

Il y a.

The third person singular of *avoir*, to have, preceded by *y*, and used impersonally, takes the meaning of "to be."

Il y a, there is (or) there are; *il n'y a pas*, there is not, there are not.

Voilà, voici.

Voilà is also to be translated by "there is," "there are," but with a different meaning. It is made up of *vois* (see, behold), and *là* (there). and is used when actually pointing to some object, or objects: *voilà des livres*, there are some books; *voilà une plume*, there is a pen. Similarly, *voici* means "here is," "here are": *voici une table*, here is a table; *voici des chaises*, here are some chairs.

Exercise IV.

1. The paper of the book. 2. The hero of the story. 3. The top of the house. 4. The child's pencil. 5. There is the pen. 6. There is the ruler. 7. The ink is in the inkstand. 8. The inkstand is on the table. 9. There is an inkstand on the table. 10. The height of the house. 11. There are a book, an inkstand, a blotting-book, a ruler and a copy-book on the table. 12. From the chair to the table. 13. The father and mother are in the house. 14. Charity is a virtue. 15. Iron is a metal. 16. The man has a brother and a sister. 17. The children have grammars. 18. There is the book of one of the children. 19. I have spoken to the woman's children. 20. I write to the brother and sister. 21. I have some pencils. 22. She has no ink. 23. You have need of pens and paper. 24. He has some good books. 25. You have pencils and paper; we have none. 26. You have some good pens. 27. The child's father has a house. 28. There is the child's father. 29. She has need of ink and paper. 30. Gold and silver are useful to men. 31. Children have no patience. 32. Patience is a virtue.

Key to Exercises I., II., III.

I.

femme, woman (*fam*).
tête, head (*tate*).
histoire, history (*ees-twahr*).
aiguille, needle (*egg-wee-ĕ*).
faubourg, suburb (*fo-boor*).
doigt, finger (*dwa*).
mauvais, bad (*mō-vāy*).
Dieu, God (*Dēē-ĕ*).
Espagnol. Spaniard (*Es-pan-yŏl*).
vérité, truth (*vĕy-rēē-tey*).
soleil, sun (*sŏ-ley-yĕ*).
février, February (*fĕy-vrēē-ey*).
mardi, Tuesday (*mahr-dēē*).
monsieur, Mr., Sir (*mĕ-sēē-ĕ*).
maître, master (*māytr*).
Noël, Christmas (*Nŏ-el*).
mademoiselle, Miss (*ma-dĕ-mwa-zel*).
nord, north (*nōr*).
beaucoup, much (*bō-kŏŏ*).
quoi, what (*kwah*).
hiver, winter (*ēē-verr*).
damner, to damn (*dah-ney*).
sculpter, to carve (*skül-tey*)
prompt, prompt (*pron^g*).
cuiller, spoon (*kwēē-yey*).
maison, house (*may-zon^g*).
sous, under (*soo*).
misère, misery (*mēē-zairr*).
poison, poison (*pwah-zon^g*).
poids, weight (*pwa*).
paix, peace (*pey*).
sept, seven (*set*).
huit, eight (*weet*).
neuf, nine (*nĕf*).
dixième, tenth (*dēē-zēē-ame*).
signe, sign (*seen-ye*).
amer, bitter (*ahmerr*).
prix, prize, pri e (*prēē*).
Guise, Guise (*Gweez*).
cri, cry (*krēē*).
babil, chatter (*babee-ye*).
ville, town (*vēēl*).
œuf, egg (*ĕf*).
sœur, sister (*sĕr*).
plomb, lead (*plon^g*).
mais, but (*may*).
chef-d'œuvre, masterpiece (*shey-dĕvr*).
citoyen, citizen (*seet-wa-yawn^g*).
gloire, glory (*glwarr*).

II.

A. *Auto(m)ne, (h)istoir(e), san(g), (a)oû(t), doi(gt), septembr(e), port(e), cham(p), sud, port(ent), plom(b), dange(r), lac, vin(gt), mer, faubour(g), pai(x), outi(l), blan(c), pri(x), Jésu(s), nez, cer(f), beaucou(p), bari(l), péril, mo(n)sieu(r), amer, chez, cle(f), scul(p)te(r), ba(p)têm(e), hier, cou(p), por(c), cor(ps), dan(s), da(m)ner, (h)omm(e), hach(e), serf, dra(p), sou(s), mai(s), neuf, bor(d), genti(l), gosie(r), e(t), t(h)é.*

B. *Lau-rier, cha-lou-pe, sour-cil, plai-sir, mar-di, vé-ri-té, a-près, four-chet-te, a-gneau, poi-gnard, gé-né-ra-le-ment, a-mi, é-cri-tu-re, par-ler, mer-lan, mon-trer, troubler, den-rée, vir-gu-le, con-sen-tir, en-la-cer, beau-coup, de-voir, dé-jà.*

III.

a = aigu; g = grave; c = circonflex.

A. *Même, c; bergère, g; blé, a; mûr, c; dés, a; mère, g; déjà, a, g; paraît, c; côté, c, a; près, g; prés, a; tête, c; été, a, a; fâché, c, a; fenêtre, c; lèvre, g; être, c; à, g; où, g; dû, c; général, a, a; maître, c; succès, g; témérité, a, a, a; île, c.*

B. *Je n'ai d'autre ambition; c'est moi; l'oreille; l'homme; l'oiseau; il faut qu'il parte; la crainte qu'elle m'a causée; lorsqu'un enfant n'obéit pas; s'il vient; le héros; l'héroïne; presque en même temps; quelque autre; le onze juillet; jusqu'à Londres.*

Continued

LATIN Continued from page 605 By Gerald K. Hibbert, M.A.

SECTION I. GRAMMAR.

Peculiarities and Irregularities of the Noun. 1. Many nouns have no plural—*e.g.*, proper names and abstract nouns, and words like argentum (*silver*), aurum (*gold*), ferrum (*iron*), aër (*air*), æther (*sky*), etc.

2. Many nouns have no singular: Certain names of towns, as Thebæ (*Thebes*), Athenæ (*Athens*); parts of the body; names of feasts or days, as feriæ (*holiday*), nundinæ (*market-day*); and words like divitiæ (*riches*), liberi (*children*), manes (*ghosts*), penates (*household gods*), mœnia (*town walls*), tenebræ (*darkness*), etc.

3. Some nouns change their meaning in the plural:

Singular.	*Plural.*
castrum, *a fort*	castra, *a camp*
ædes, *a temple*	ædes, *a house*
aqua, *water*	aquæ, *a watering-place*
auxilium, *assistance*	auxilia, *auxiliary troops*
copia, *plenty*	copiæ, *supplies, troops*
impedimentum, *a hindrance*	impedimenta, *baggage*
litera, *a letter* (of the alphabet)	literæ, *an epistle*
opem (acc.), *help*	opes, *resources*
opera, *work*	operæ, *workmen*
rostrum, *a beak*	rostra, *the pulpit at Rome*
ludus, *play*	ludi, *public games*
carcer, *prison*	carceres, *the barriers* (in horse races)
etc.	etc.

4. Many nouns are defective in case:

The following have no nominative: dapem (*feast*), frugem (*fruit*), opem (*help*), precem (*prayer*), vicem (*change*).

Vis (strength), is thus declined:

	Singular.	*Plural.*
N.V.	vis	vires
Acc.	vim	vires
Gen.	(none)	virium
Dat.	(none)	viribus
Abl.	vi	viribus

Other defective nouns are forte (*by chance* [abl.]), sponte (*by one's own choice* [abl.]), fas (*right*), nefas (*wrong*), nihil (*nothing*), opus (*need*), instar (*likeness*), necesse (*necessity*), mane (*morning*). These are practically indeclinable.

The following list of nouns with their genitive singular and nominative plural will be useful. If these two cases of a noun are known, the whole noun can be declined: for if the nominative plural ends in *a*, the noun is neuter, and therefore the accusative will be the same as the nominative, both singular and plural.

Nom. singular	*Gen. singular*	*Nom. plural.*
pecus, *f.* *head of cattle*	pecudis	pecudes
pecus, *n.* *cattle*	pecoris	pecora
grus, *f.* *crane*	gruis	grues
mus, *com.* *mouse*	muris	mures
incus, *f.* *anvil*	incudis	incudes
vulgus, *n.* *common people*	vulgi	vulga
virus, *n.* *poison*	viri	vira
tellus, *f.* *earth*	telluris	tellures
supellex, *f.* *furniture*	supellectilis	supellectiles
vas, *m.* *bail*	vadis	vades
vas, *n.* *vessel*	vasis	vasa
pecten, *m.* *comb*	pectinis	pectines
cucumis, *m.* *cucumber*	cucumeris	cucumeres
pulvis, *m.* *dust*	pulveris	pulveres
cuspis, *f.* *shield*	cuspidis	cuspides
glis, *m.* *dormouse*	gliris	glires
lis, *f.* *lawsuit*	litis	lites
obex, *com.* *bolt*	obicis	obices
mas, *m.* *male*	maris	mares
seges, *f.* *crop*	segetis	segetes
merges, *f.* *sheaf*	mergitis	mergites
merces, *f.* *reward*	mercedis	mercedes
heres, *com.* *heir*	heredis	heredes
compes, *f.* *fetter*	compedis	compedes
caro, *f.* *flesh*	carnis	carnes
margo, *com.* *border*	marginis	margines
cupido, *f.* *desire*	cupidinis	cupidines
pugio, *m.* *dagger*	pugionis	pugiones
nex, *f.* *death*	necis	neces
nix, *f.* *snow*	nivis	nives
senex, *m.* *old man*	senis	senes
bos, *com.* *ox*	bovis	boves
Jupiter, *m.* *Jupiter*	Jovis	—
iter, *n.* *journey*	itineris	itinera
jecur, *n.* *liver*	jecinoris (*or* jecoris)	jecinora

Nom. singular.	*Gen. singular.*	*Nom. plural.*
gigas, *m.* *giant*	gigantis	gigantes
jus, *n.* *right*	juris	jura
falx, *f.* *scythe*	falcis	falces
vates, *com.* *prophet*	vatis	vates

NOTE. *Bos* has genitive plural *boum*; dative and ablative plural *bobus* or *bubus*.

Respublica (commonwealth) and *jusjurandum* (oath), decline both halves: accusative *rempublicam*, genitive *reipublicæ*, ablative *republica* (*res* is fifth declension like *dies*). So, accusative *jusjurandum*, genitive *jurisjurandi*, etc

[The genitive and genders of other nouns can be looked up in the dictionary.]

The following rhyme may be useful as an aid to remembering the exceptions to the rule that parisyllables form their genitive plural in *-ium*, and imparisyllables in *-um*:

"In *-ium* terminate glis, lis,
Mas, mus, and nix, falx, faux, and vis:
But *-um* ends juvenis and frater,
Ambages, vates, senex, pater,
With canis, volucris, and mater."

SECTION II. SYNTAX.

Ablative: Further Uses. *The ablative is, more than any other, an adverbial case; it is the case of circumstances which attend action, and limit it adverbially. It answers the questions: Whence? How? From what cause? When? Where?*

1. ABLATIVE OF TIME. This answers the questions *When? Within what time? How long before or after?* (Contrast this with the accusative of time, denoting *duration*—*e.g.*, decem *annis* post urbem conditam obiit = he died 10 *years after* the founding of the city; but, decem *annos* vixit = he lived *for* 10 *years*.)

2. ABLATIVE OF PLACE. This is used without a preposition, when the question is "By what road?" or (of a town or small island) "Whence?"—*e.g.*, Ibam forte *Via Sacra* = I was going by chance *on the Sacred Road*; *Corintho* fugit = he fled *from Corinth*; (So *domo* = from home; *rure* = from the country).

Under this heading we may treat the locative case, practically obsolete in classical Latin, and largely replaced by the ablative. The locative answered the question *Where?* and ended in *-i*—*e.g.*, *domi*, at home; *ruri*, in the country; *humi*, on the ground; *belli*, at the wars. The ablative is always used for the locative in names of towns and small islands of the 3rd declension, and in plural names of towns of the 1st and 2nd declension—*e.g.*, *Athenis*, at Athens; *Neapoli*, at Naples. But if the town or small island is a singular noun of 1st or 2nd declension, the genitive is used—*e.g.*, *Romæ*, at Rome (old locative was *Romai*); *Corinthi*, at Corinth.

3. THE ABLATIVE OF ORIGIN is used after verbs and participles—mostly—though not always—without a preposition—*e.g.*, *Jove* natus, born of Jupiter.

4. ABLATIVE OF INSTRUMENT AND CAUSE—*e.g.*, Boni oderunt peccare virtutis *amore* = the good hate to sin *from love* of virtue (cause); *gladio* interfectus est = he was slain *with the sword* (instrument).

5. ABLATIVE OF THE AGENT. When the "instrument" is a person, not a thing, the preposition *a* or *ab* is necessary—*e.g.*, Cæsar *a Bruto* pugione interfectus est = Cæsar was slain *by Brutus* with (*i.e.*, by means of) a dagger. (But when "with" = "*together with*," the preposition "*cum*" must be used—*e.g.*, *cum fratre meo* veni = I came *with my brother*.)

6. ABLATIVE OF MANNER. This, being purely adverbial, is one of the commonest uses of the ablative—*e.g.*, Injuria fit *duobus modis*, aut *vi* aut *fraude* = wrong is done *in two manners*, either *by force* or *by fraud*. Similarly, *hoc modo* = in this manner; *casu* = by chance; *consilio* = by design, on purpose; *jure* = rightly, by right; etc.

7. ABLATIVE OF QUALITY AND ACCOMPANIMENT.

(*a*) Quality—*e.g.*, Senex *eximio ingenio* = an old man *of wonderful ability*. (The noun in the ablative must have an adjective with it: we could not say "*senex ingenio*.")

(*b*) Accompaniment—*e.g.*, hoc feci *summa diligentia* = I have done this *with the utmost care*. (If we omitted the adjective, we should have to insert "cum"—*e.g.*, hoc feci *cum* diligentia.)

8. ABLATIVE OF PRICE. Used with verbs of *buying* and *selling*, usually when some definite figure is given. (Otherwise, and especially after verbs of *valuing* and *esteeming*, the genitive is used.) Anulum *viginti nummis* vendidit = he sold the ring *for twenty nummi*.

9. ABLATIVE OF MEASURE—*e.g.*, Sol *multis partibus major* est quam luna = the sun is *many times larger* (lit. *by many parts*) than the moon; *quo* citius, *eo* melius = the sooner, the better (lit. *by what* the sooner, *by that* the better).

10. ABLATIVE OF COMPARISON—*e.g.*, Puto mortem *dedecore* leviorem = I think death easier *than disgrace*.

11. The ablative is used after the following:

(*a*) Verbs: *Abounding, filling*, etc., and their opposites, *depriving of, being without*. Also the deponent verbs *fruor, fungor, utor, vescor, potior, dignor*. (It is really quite regular to have the ablative after these verbs; *utor*, for example, means "I serve myself *with*," and so comes to mean "I use.")

(*b*) Adjectives: *dignus* (worthy), *indignus* (unworthy), *fretus* (relying on), *contentus* (content with), *præditus* (endowed with)—*e.g.*, *laude dignissimus* = most worthy *of praise*.

(*c*) Nouns: *opus* (need), and *usus* (use)—*e.g.*, opus est mihi *argento* = I have need of silver.

Passage to be Turned into Latin.

"Come unto Me all ye who are weary and heavy laden, and I will cause that ye may rest. Take up My yoke upon you and learn from Me, because I am meek and lowly in heart; and ye shall find rest unto your souls. For my yoke is easy, and My burden is light."

Translation of Above.

(From Beza's version of the New Testament.)

Venite ad me omnes qui fatigati estis et onerati, et ego faciam ut requiescatis. Attolite jugum meum in vos, et discite a me, quod mitis sim et humilis corde; et invenietis requiem *animabus* (1) vestris. Jugum *enim* (2) meum facile est, et onus meum leve est.

Notes. (1). *Animabus* is the dative plural of *anima*, to distinguish it from *animis*, the dative plural of *animus* (cp. *filiabus* and *filiis*).

(2). *Enim*, like *autem*, can never be the first word of a sentence.

Section III. TRANSLATION.

The following passage is from Vergil's "Æneid." Vergil was a Latin poet, who lived at the beginning of the Christian era, under the Emperor Augustus. His most famous work is the "Æneid," a history of the Fall of Troy and the adventures of Æneas thereafter. There are twelve books, and this passage is from Book II., lines 234-249. It describes the stratagem of the Wooden Horse (containing armed men), by which the Greeks brought about Troy's fall. The Trojans dragged the horse into their city as a prize of war, and in the night the Greeks hidden inside the horse emerged and opened the gates to their comrades outside.

[The beginner should read a book of Cæsar and a book of Vergil as early as possible. Welch and Duffield's "Helvetian War" is strongly recommended].

Æneas is relating the events of the fatal night.

[*And* is often translated by *-que* joined to the end of a word.]

Dividimus muros, et mœnia pandimus urbis.
Accingunt omnes operi, pedibusque rotarum (*a*)
Subjiciunt lapsūs (*a*), et stuppea vincula collo
Intendunt. Scandit fatalis machina muros
Feta armis. Pueri circum innuptæque puellæ
Sacra canunt, funemque manu contingere gaudent.
Illa (*b*) subit, mediæque minans inlabitur (*c*) urbi.
O patria, O divom (*d*) domus Ilium, et incluta bello
Mœnia Dardanidum! quater ipso in limine portæ
Substitit (*e*), atque utero sonitum quater arma dedere (*f*):
Instamus, tamen, immemores cæcique furore,
Et monstrum infelix sacrata sistimus arce.
Nos delubra deum (*g*) miseri, quibus ultimus esset
Ille dies, festa velamus fronde per urbem.

Notes. (*a*). *Lapsus rotarum* = gliding wheels, or rollers (literally, glidings of wheels; *lapsus* is acc. pl., 4th decl., and is direct object to *subjiciunt*; *pedibus* is indirect object, and therefore dative).

(*b*). *Illa* = it, *i.e.*, machina: nom. fem. sing.

(*c*). *Inlabitur*, though passive in form, is active in meaning: a deponent verb.

(*d*). *Divom* = divorum = deorum.

(*e*). Perfect of *subsisto*.

(*f*). = *dederunt*.

(*g*). *Deum* is often used for deorum, gen. pl.

Key to Above Passage.

We sunder the walls, and lay open the fortifications of the city. All gird themselves for the work, and put rolling wheels under its (*i.e.*, the wooden horse's) feet, and fasten hempen bands on its neck. The fated engine climbs the walls, big with arms. Around it boys and unwedded girls sing hymns, and rejoice to touch the rope with their hand (*i.e.*, to help to pull the horse into the city). It approaches, and glides threatening into the midst of the city. O native land! O Ilium (Troy), home of the gods, and fortresses of the Dardanidæ (Trojans) renowned in war! Four times in the very gateway did it halt, and four times the arms rattled (literally, gave a sound) in its womb. Yet we press on, unmindful and blind with frenzy, and plant the ill-omened monster in our sacred citadel. We deck the shrines of the gods throughout the city with festal foliage, wretched people, to whom that day was our last.

Continued

ENGLISH

Continued from page 608

By Gerald K. Hibbert, M.A.

The Indicative Mood. There is no difficulty about this mood. It is used whenever we make a statement or ask a question about something which we regard as a matter of fact, apart altogether from our conception of it—*e.g.*, "London *is* burning," "How *fares* it with the happy dead?"

The Indicative may even be used to express condition, provided that the condition or supposition relates to some matter of fact rather than to some "matter of conception" (to use a phrase of Mason's)—*e.g.*, "If he *betrays* me, he shall smart for it." This will be more fully explained later on.

The Imperative Mood expresses a command, and is therefore strictly used only in the second person: "*Charge*, Chester, *charge!*" "*Pray* without ceasing." When we wish to express a command or exhortation in connection with the first or third person, we use either the imperative (second pers. sing.) of *let*, followed by the infinitive (as, "*Let* us not *be* weary in well-

doing," "*Let* there *be* light"), or the subjunctive mood of the verb in question (as, "Blessed *be* God"). The future imperative is not often used now; it was common in prohibitions (*cf.* the Ten Commandments: "Thou *shalt* not . . .").

THE SUBJUNCTIVE MOOD was so called because it was most often used in subordinate ("subjoined") sentences. It is impossible for the Subjunctive to be used in a simple direct statement or question. It is used chiefly in (1) Conditional clauses, introduced by *if* (though not always, as we have seen under "Indicative"); (2) Purpose clauses, introduced by "in order that" or "lest," as "Kiss the Son, lest he *be* angry"; (3) Wishes, as "O that he *were* here!"

Although the Subjunctive is usually found following conjunctions like "if," "unless," "provided that," etc., the conjunction is not a part of the mood, nor is the Subjunctive always necessary after it. It depends on whether the speaker is emphasising the fact, or his conception of the fact.

The Subjunctive Mood is becoming more and more rarely used in English. It is being replaced (1) by the Indicative (instead of "If he *were* here, all would be well," it is becoming increasingly common to say, "If he *was* here," etc.); (2) by the use of some auxiliary verb, as *may, might, should*. We should now say as a rule, "Kiss the Son, lest he *should* be angry." But in so doing we lose the delicate shade of meaning that distinguishes the one mood from the other, and we thereby rob the language of one of its priceless charms.

THE INFINITIVE MOOD. The Infinitive is a verbal noun. It is a noun because it can stand as the subject or the object of a verb, as "*To be* is nobler than *to have*" (subject), "Learn *to do* well" (object). It is a verb because it can govern an object, as "'Tis best *to keep the nerves at strain*."

Although the Infinitive is generally used with the preposition *to* before it, the *to* is not a part of the Infinitive. Many verbs are followed by the Infinitive without *to*; these include the auxiliaries *do, shall, will*, the verbs *bid, dare, make, let, can, may, must, need*, and some verbs denoting the operation of the senses, as *hear, see, feel*.

In old English the Infinitive ended in *-an* or *-en* (as, *sawan* = to sow), and had not the preposition *to* before it. The *to* was only prefixed when the infinitive was used to denote purpose, as "I come *to bury* Cæsar, not *to praise* him." Here *to* has its proper force, and = "in order to." This strictly proper use became gradually more and more extended, until the *to* came to be regarded as an indispensable part of the Infinitive.

The Infinitive is sometimes used in exclamations, as "*To think* that I could have been so foolish!"

CAUTION. (1) Beware of using what is called the *Split Infinitive*; in other words, do not insert any word or words between the *to* of an infinitive mood and its verb. It is far better to say "I must ask you *kindly to excuse me*" than "I must ask you *to kindly excuse* me."

(2) The Past Infinitive (*e.g., to have seen*) needs careful handling when used after another verb in the past tense. Many people will say "I should *have liked* to *have seen* you," which is incorrect; it should be "I should *have liked* to *see* you."

GERUNDS AND PARTICIPLES. The gerund (Latin *gerere* = to carry on) is a verbal noun like the Infinitive, and is similar in meaning to the Infinitive. The participle is a verbal adjective (Latin, *participare* = to partake, because it "partakes" of the nature both of verb and adjective). As these are not "finite" moods, they are generally classed among the "infinite" moods.

The gerund, being a verbal noun, can be used in most of the constructions of a noun. It is formed from the verb by adding *-ing*. Gerunds are often confused with abstract nouns ending in *-ing* (Anglo-Saxon *-ung*), though they are really quite distinct. Thus, it is correct to say either "By *dredging* the river" (gerund), or "By the *dredging* of the river" (noun), but it is incorrect to say "By the dredging the river," or "By dredging of the river." The rule is quite simple: "When *the* precedes, *of* must follow; but if *the* is omitted, *of* must also be omitted." We thus see that a gerund, when formed from a transitive verb, can govern an object just like any other part of the verb. The gerund, like the Infinitive, can be either the subject or the object of a verb—as, "*Walking* is capital exercise" (subject), "I like *walking*" (object). Although the gerund has the same meaning as the Infinitive, it cannot always be used instead of it; for instance, after prepositions the gerund is almost always used, as "*Of making* many books there is no end." The gerund can, of course, be used in the passive voice as well as in the active—as, "The joy of being loved."

In such expressions as "I go *a-fishing*," "The ark was *a-preparing*," "The house is *a-building*," "There came three ships *a-sailing*," (where the *a-* represents *on*) we must treat the form in *-ing* not as the gerund, but as a modern form of the old abstract noun ending in *-ung*.

Many compound nouns are formed from gerunds, as "*skipping*-rope" (a rope for skipping). Contrast such a compound noun with others like "*humming*-bird," which does not mean "a bird for humming," but "a bird which hums." "Skipping-rope" could not be rendered "a rope which skips." This shows the difference between a gerund (skipping) and a participle (humming), and we are thus brought on to—

PARTICIPLES, or verbal adjectives. These, being adjectives, cannot be used as the subject or object of a verb, or after a preposition; and, like all adjectives, they refer to some noun about which they specify something.

There are two participles formed by inflexion, the *Present* or *Imperfect Participle*, and the *Past Participle*.

1. The imperfect participle is always active and always ends in *-ing* (like the gerund, with which it is often confused). Examples:

"Him walking on a sunny hill he found."
—*Paradise Regained.*

[Here *walking* is a verbal adjective agreeing with *Him.*]

"Thinking he had come, I opened the door."

[*Thinking* is a verbal adjective agreeing with *I.*]

"But, as I rose out of the laving stream,
Heaven opened her eternal doors . . . ."

[*Laving* is a verbal adjective qualifying *stream.*]

To distinguish a gerund from an imperfect participle, ask the question "Does the word in question play the part of a noun or an adjective?" If the former, it is a gerund; if the latter, a participle. Contrast "By *talking* my throat gets tired" (gerund) with "*Talking* loudly, they left the room" (Participle, agreeing with *they*).

It is a very common mistake to use the participle where a gerund should be used. To say "I heard of *you* winning the prize" is wrong; it should be *your*, because *winning* is the gerund (*i.e.*, a noun), and it is as wrong to use *you* in this case as to say "Lend me *you* watch." *You* could only be used if *winning* were a participle—*e.g.*, "You, *winning* the prize, are a happy man." In the case of personal and relative pronouns, the gerund and the possessive (*my, thy, his,* etc.) should be used, not the participle and the objective—as, "I am sorry for *his* (not *him*) lapsing into bad ways," "They told me of *his* (not *him*) running away." In all other cases there seems to be a diversity of opinion among the authorities. Some will say "I had no knowledge of my *cousin* being there" (participle); others, "I had no knowledge of my *cousin's* being there" (gerund). The latter is preferable.

We thus see that there are three totally different classes of words in *-ing*. (1) The abstract noun, as, "The *courting* of danger is foolish." (2) The gerund, as, "He perished in *courting* danger." (3) The participle, as, "The foolish fellow, *courting* danger, met his death."

2. The past participle ends in *-d, -ed, -t,* or *-en*. It is always passive, provided that the verb from which it is formed is transitive, as "*Refreshed* by our night's rest, we resumed our journey next morning."

[Of course, the past participle can be compounded with the verb "to have" to form an active verb, as "I *have refreshed* myself."]

The Anglo-Saxon past participle was formed by prefixing *ge-* to the verb; traces of this remain in the words *ydrad* (dreaded), *yclept* (called), *yclad* (clothed), *yslaked* (slaked). *Cf.* the German method of forming the past participle, as *gefunden*, from *finden*.

Participles often come to be used as mere adjectives—*e.g.*, "a *frowning* hill," "a *broken* reed."

In addition to these two participles proper, the following compound participles are used in English:

a. The past participle compounded with "having," to form a perfect participle active, as, "*Having spoken* these words, he died."

b. The past participle compounded with "being," to form an imperfect participle passive, as, "*Being warned.*" Also the same compounded with "having been," to form a perfect participle passive, as, "*Having been warned*"

c. A loose kind of future participle, as, "*About to die,* we salute you," "*About to be killed.*"

EXERCISES.

Correct the Following Sentences:

1. I had wanted to have seen him.
2. Trusting you are well, believe me yours truly.
3. In the reading the Psalms, the clerk made many mistakes.
4. If he was to go, he would regret it.
5. Had he have gone he would have regretted it.

In the following sentence classify the words ending in *-ing* into nouns, gerunds, and participles:

"A loving father, lying dying, on seeing his children crying, said, 'Dying is easy; it is living that is trying. Prepare for dying by living noble lives.'"

Key to Sentences on Page 608.

a. "It is I" (who am there).
b. "Themselves" should be "himself."
c. Insert "who" before "is."
d. "Whom" (objective after "mean").
e. "Their" should be "his."

Tense. So far we have considered Voice and Mood of verbs: we now come to *Tense, Number* and *Person.* The different forms assumed by a verb to indicate Time are called Tenses (Latin *tempus* = time).

There are three natural divisions of time—Past, Present, and Future; and corresponding to these are three main tenses in Grammar. But an action in each of these three tenses can be looked at from three distinct points of view—as Incomplete, as Complete, and as Indefinite. We thus get *nine* Primary Tenses, as follows:

	Incomplete.	Complete.	Indefinite.
	(1)	(2)	(3)
Past *Act.*	I was loving	I had loved	I loved
,, *Pass.*	I was being loved	I had been loved	I was loved
	(4)	(5)	(6)
Pres. *Act.*	I am loving	I have loved	I love
,, *Pass.*	I am being loved	I have been loved	I am loved
	(7)	(8)	(9)
Fut. *Act.*	I shall be loving	I shall have loved	I shall love
,, *Pass.*	I shall be being loved	I shall have been loved	I shall be loved.

In addition to these nine Primary Tenses

there are three Secondary ones, called *Perfect Continuous* (in the Active voice only):

1. I have been loving.
2. I had been loving.
3. I shall have been loving.

Notice that nearly all the tenses are formed by using auxiliary verbs, *be*, *have*, etc. Such tenses are called *Compound* tenses, as opposed to *Simple* tenses, which contain only a single word (*I love*, *I loved*). An alternative form of the past and present indefinite tenses is often used, "I *did* love," "I *do* love." Sometimes the *do* and the *did* are used for emphasis, as "I *did* think you would have come earlier." But often there is no emphasis attached to them, as, "The young lions *do* lack and suffer hunger." Similarly, in the well-known passage from Samuel, "They set bread before him and he *did* eat," there is no emphasis intended, though the temptation to lay stress on the *did* is almost irresistible. *Do* and *did*, however, are commonly used in questions and in negative sentences, as "*Do* men say?" rather than "Say men?" "I *do* not like you" rather than "I like you not."

Use of the Tenses. PAST. The simple past tense (past indefinite) is used in three ways:

1. It points out, without any qualification, that something occurred in the past, as: "William of Normandy *conquered* England in 1066."

2. It is used with the meaning of an imperfect or incomplete tense: "And as they *sat* and *did eat*, He said, etc." (= *were sitting and eating*).

3. It expresses what used to happen frequently or customarily: "In those days men *travelled* well-armed" (= *used to travel*).

PRESENT. The simple present tense (present indefinite) is used in the following senses:

1. It states what is actually taking place, as "Swift to its close *ebbs* out life's little day"—*i.e.*, "is ebbing at this moment."

2. It denotes what regularly takes place, as: "Each morning *sees* some task begin, Each evening *sees* its close."

3. It often stands for the future, especially after *when*, *as soon as*, etc., as: "We *go* home to-morrow," "As soon as I *hear*, I will let you know," "When the Son of Man *cometh*, shall He find faith on the earth?"

4. It is sometimes used for the sake of vividness in describing past events, the speaker adopting the present tense in order to be more graphic, as:

"The English shafts in volleys hail'd,
In headlong charge their horse assail'd:
Front, flank, and rear, the squadrons *sweep*
To break the Scottish circle deep,
That fought around their King."
("Marmion.")

FUTURE. This tense is not simple, but compound, the two auxiliary verbs *shall* and *will* being used for its formation. There is a difference in the use of these two auxiliaries.

Shall originally denoted obligation or authority (from Anglo-Saxon *sculan*, to owe), a sense which it retains in the second and third persons of the future, as: "In the sweat of thy face *shalt* thou eat bread," "Thou *shalt* not kill," "There *shall* be no night there." But in the first person, *shall* is used for the simple future, as: "I *shall* be home by five o'clock."

Will. When *will* is used in the first person, it implies (like *shall* used with the second and third), that the action spoken of is dependent on the will of the speaker, as: "Though I should die with Thee, yet *will* I not deny Thee." But in the second and third persons, *will* usually denotes simple futurity, as: "Christmas *will* soon be here." Sometimes, however, it denotes habit or custom, as: "When the cat's away, the mice *will* play."

We thus see why it is that in the ordinary future tense, in affirmative principal sentences, *shall* is used for the first person, *will* for the second and third, as: "I *shall* be, Thou *wilt* be, He *will* be." But in dependent clauses *shall* is used for all three persons, as: "*When* the Son of Man *shall* come in His glory," etc.

Precision of Tenses in English. The use of auxiliary verbs like *do*, *have*, *be*, *shall*, etc., makes it possible to mark tense in English with the greatest possible exactness and precision. In languages that are more inflected and less analytic, this is not possible. In Latin, for example, the one word *scribo* stands for (1) I write, (2) I am writing, (3) I do write. Similarly, *scripsi* stands for (1) I wrote, (2) I have written; and so on.

Sequence of Tenses. If the verb in the principal clause of a sentence is present, future, or perfect, the verb in the dependent clause will be present or future; and if the verb in the principal clause is past, the verb in the dependent clause will be past. Examples:

$\left.\begin{array}{l}\text{“We eat}\\ \text{“We shall eat}\\ \text{“We have eaten}\end{array}\right\}$ in order that we *may* live."

"We ate in order that we *might* live."

Number. Verbs, like nouns, have two numbers, singular and plural. The plural is without inflexion in all verbs except "to be."

Person. Verbs are inflected for Person; there are three persons, First, Second, and Third (the person speaking, the person addressed, the person spoken of).

Conjugation of Verbs.

VERB "TO BE."

Infinitive Mood.

Present.	*Past.*
(To) be	(To) have been
(To) be being	(To) have been being

Participles.

Incomplete	*Perfect.*	*Compound Perf.*
being	been	having been

Indicative Mood.

Past.	Present.	Future.
	Indefinite.	
I was	I am	I shall be
	Incomplete (or Continuous).	
I was being	I am being	I shall be being
	Complete (or Perfect).	
I had been	I have been	I shall have been
	Perfect Continuous.	
I had been being	I have been being	I shall have been being

Subjunctive Mood (no future tenses).

Past.	Present.
Indefinite.	
I were, *or* might be	I be, *or* may be
Incomplete.	
I were being, *or* might be being	I be being, *or* may be being
Complete.	
I had been, *or* might have been	I have been, *or* may have been
Perfect Continuous.	
I had been being, *or* might have been being	I have been being, *or* may have been being

A third form of the Past tense is formed with *should* instead of *might*—thus, I should be; I should be being; I should have been; I should have been being.

Imperative Mood.

Singular.	*Plural.*
Be (thou)	Be (ye)

The above is the full conjugation of the verb *to be*, but, of course, there are some of these forms which are seldom, if ever, used—*e.g.*, "I had been being," "I should have been being." We use instead the participle of some such verb as *become, grow, get*, as: "I had been growing tired."

The four simple tenses are now given in full:

Indicative Mood.

Present Indefinite.		*Past Indefinite.*	
(I) am	(We) are	(I) was	(We) were
(Thou) art	(You) are	(Thou) wast *or* wert	(You) were
(He) is	(They) are	(He) was	(They) were

Subjunctive Mood.

Present Indefinite.		*Past Indefinite.*	
(I) be	(We) be	(I) were	(We) were
(Thou) be	(You) be	(Thou) wert	(You) were
(He) be	(They) be	(He) were	(They) were

In the compound tenses there is no inflexion, except of the auxiliary verbs "have, shall," etc., which will be given later.

The conjugation of the verb *to be* is made up from three different roots: (1) *as*, Latin *es*, which gives *am* (as-m), *art* (as-t), and *are* (as-e); (2) *be*; (3) *wes*, which gives *was* and *were*.

All the tenses of *be* can be used as auxiliaries to form the compound tenses of other verbs ("I shall have been writing"), but the Incomplete and Perfect Continuous tenses are used only for the Passive Voice ("I was being robbed").

Verb "To Have."

Infinitive Mood.

Present.	Past.
(To) have	(To) have had
(To) be having	(To) have been having

Participles.

Incomplete.	*Perfect.*	*Compound Perf.*
having	had	having had

Indicative Mood.

Past.	Present.	Future.
	Indefinite.	
I had	I have	I shall have
	Incomplete.	
was having	I am having	I shall be having
	Complete.	
I had had	I have had	I shall have had
	Perfect Continuous.	
I had been having	I have been having	I shall have been having

Subjunctive Mood.

Past.	Present.
Indefinite.	
I had I might have I should have	I have I may have
Incomplete.	
I were having I might be having I should be having	I be having I may be having
Complete.	
I had had I might have had I should have had	I have had I may have had
Perfect Continuous.	
I had been having I might (*or* should) have been having	I have been having I may have been having

Imperative Mood.

Singular	*Plural.*
Have (thou)	Have (ye)

The four simple tenses in full:

Indicative Mood.

Present Indefinite.	
(I) have	(We) have
(Thou) hast	(You) have
(He) hath, *or* has	(They) have

Past Indefinite.	
(I) had	(We) had
(Thou) hadst	(You) had
(He) had	(They) had

SUBJUNCTIVE MOOD.

Present Indefinite.

(I) have	(We) have
(Thou) have	(You) have
(He) have	(They) have

Past Indefinite.

(Same as Indicative.)

Had is shortened from *haved*, *hast* from *havest*, *hath* from *haveth*. *Hath* is now very rarely used.

Only the Indefinite tenses of *have* can be used as auxiliaries to form compound tenses of other verbs.

Analysis of Sentences

We can now turn aside for a moment from our study of words as independent units (the study of *Accidence*), and can deal with them in their relationship to other words grouped with them to form a sentence. The unit of speech is the sentence, and it is quite as important to be able to break a sentence up into its component parts as it is to be able to compare an adjective or conjugate a verb. We cannot properly parse a word—*i.e.*, say to what part of speech it belongs—until we see it in a sentence; and before we can parse it then as it should be parsed, we must make a mental analysis of the sentence. Analysis, therefore, logically comes before parsing.

Analysis of a Simple Sentence—*i.e.*, a sentence that has only one Subject and one Predicate. In every sentence there must be a subject and a predicate; this is the irreducible minimum, as "Fire burns." In addition, there may be a word or words limiting or qualifying either the subject or the predicate, or both, as: "*This* fire burns *well*." Finally, if the predicate is a transitive verb it will take an object, and this object, too, may have a word or words limiting it, as: "Fire burns your finger" (*finger* being object, and *your* limitation of object).

As a rule, a simple sentence does not consist of more than these six parts:

1. Subject.
2. Limitation of Subject.
3. Predicate.
4. Limitation of Predicate.
5. Object.
6. Limitation of Object.

For example: "The freshening breeze of eve unfurled that banner's massy fold" consists of the following five parts:

Subject.	*Limitation of Subject.*	*Predicate.*	*Object.*	*Limitation of Object.*
breeze	1. The freshening 2. of eve	unfurled	fold	that banner's massy

Again: "Here rests his head upon the lap of earth A youth, to fortune and to fame unknown."

Subject.	*Limitation of Subject.*	*Predicate.*	*Limitation of Pred.*	*Object.*	*Limitation of Object.*
youth	1. A 2. to fortune and to fame unknown.	rests	1. Here 2. upon the lap of earth	head	his

Sometimes the predicate consists of a verb and a complement, especially after verbs of *making*, *calling*, etc. For example: "Cromwell's enemies have often called him a bloodthirsty monster." This is analysed as follows:

Subject	*Limitation of Subject.*	*Predicate.*		*Limitation of Complement.*	*Limitation of Predicate.*	*Object.*
		Incomplete Predicate.	*Complement.*			
enemies	Cromwell's	have called	monster	a bloodthirsty	often	him.

Although analysis robs a passage of its beauty and poetry of expression, it nevertheless lays bare the structure of the sentence. From a grammatical point of view a sentence is not grasped until it has been mentally analysed and all its component parts set forth in their *utter nakedness*.

KEY TO EXERCISES ON PAGE 757.

1. I had wanted to see him.
2. Trusting you are well, I remain, yours truly (in the faulty sentence the participle *trusting* agrees with *you*, which is the suppressed subject to *believe*; it therefore means: "Do you, trusting you are well, believe me," which is nonsense).
3. Either "In *reading* the Psalms" (gerund) or "In the *reading* of the Psalms" (abstract noun).
4. If he were to go, he would regret it (subjunctive).
5. If he had gone (*or*, had he gone), etc.

Continued

DUTIES OF THE UPPER SERVANTS

The Butler's Duties at Table. The Wine-cellar. The Housekeeper's Duties. Care of the Linen-press and Store-cupboard. The Valet

Continued from page 616.

By A. EUNICE T. BIGGS

THE BUTLER

The butler is the chief manservant in the household, except in the case of a few wealthy families where a very large retinue of menservants is kept, at their head being the house-steward and chamberlain. All the menservants whose duties are executed indoors live in the house; those whose duties are concerned with outdoor work, such as the gardeners and the coachman, etc., live out of the house. The head-gardener and coachman are generally each given the use of a small house or cottage, either on the estate or in the vicinity, this being in addition to their ordinary wages. Certain indoor servants have special privileges connected with their duties. For example, the valet will have little expense connected with his own wardrobe, since he has no livery, and can therefore wear his master's discarded clothes.

The butler, together with the housekeeper, takes precedence of all the other servants, and his duties are very responsible ones. Besides being expected to superintend the other menservants, and to see that their duties are properly executed, he has charge of all the valuable articles in daily use, and he is entirely responsible for the management of the wine-cellar. It is therefore obvious that the moral integrity of the butler should be above suspicion. He will have many temptations, since he is placed by the execution of his duties in a position in which it would be exceptionally easy to defraud his master.

The Butler's Duties when Waiting at Table. The butler waits at table during breakfast, assisted by the footman. He is responsible for the proper arrangement of the table and for the serving of the breakfast dishes. He is also expected to see that the china in use at the meal is clean and the silver properly polished. After breakfast he will clear the table, taking away the plate, which is under his care. At luncheon the arrangement of the table falls to his share, as well as the waiting. At this meal the butler usually waits single-handed, as the footman is engaged in other duties. The butler's most onerous duties are performed at dinner-time. Before dinner is served he has to supervise the laying of the table, and see that the flowers, table centre, and table decorations are prettily arranged. He will also place the silver on the table, and see that every necessary article is in readiness.

When the dinner is ready, he brings in the first course, and announces in the drawing-room that dinner is on the table. He then stands near the dining-room door as the family come into the room, and closes it after the last to enter. When the diners are all seated he approaches the table. In some houses the master serves many of the dishes, which are, in such a case, placed in front of him. The butler stands behind his chair, removes the covers, and hands them to the other servants-in-waiting to carry out. If, on the other hand, the dishes are served at the side table, the duty of dispensing them will devolve on the butler. He will serve the soup, and then cross to the sideboard to pour out the sherry and madeira taken after that course.

The Serving of Wine, and Carving. When the first course is ended, the butler rings the bell to warn the cook that the second course may be served. He then collects the plates and dishes of the first course, hands them to the other servants to remove, takes the second course from them, places it on the table, and, after removing the covers, returns to the sideboard to dispense the wines. If the joints are served at the side table, it will be the butler's duty to carve them; he should therefore be an expert carver. Of course, at a very large dinner-party help will be needed for this part of the work, but in ordinary cases a well-trained butler will carve sufficiently quickly to serve everyone present at the table with but little delay. When the dinner is finished, the butler, assisted by the footman, removes the wine-glasses and extra silver and cutlery, and sets the table for dessert. He places the finger-bowls and fruit knives and forks before each guest, and the fruits and sweetmeats on the table. He then hands round the various dessert dishes, and stands behind his master's chair to hand the wines, etc. He sees that the room is in order, that the fire, if lighted, is replenished, that the lights are in order, and then, at a signal from the master, he and the footman leave the room.

Care of the Wine-cellar. While the guests are in the dining-room he goes to the drawing-room, arranges the windows, makes up the fire, tidies the hearth, and sees that the lights are in order. He then returns to his pantry. While the footman is clearing the table and cleaning the plates and glasses, the butler must be in readiness to answer the bell. When the guests are again assembled in the drawing-room, he will, either alone or assisted by the footman, serve the coffee. The latter is brought in on a tray, together with hot milk, cream, and sugar, and is handed to the guests in turn, each person pouring out his or her own portion, and adding milk, sugar, and cream to taste.

The chief and most important duty of the butler is to take proper charge of his master's wine-cellar, and this he must be fully competent to do. We shall deal later with this part of his work; for the present we have confined

ourselves to the minor portions of his daily routine. In brief, his duty is to be in attendance at every meal, including that of tea, to see that the table is properly set and that the service is as it should be in every way. In the evening the butler brings the candles at a time fixed by the master and mistress.

The Butler's Duties at Night. After the family have retired it is his duty to go the round of the house, seeing that all the doors and windows are safely bolted and barred, that all lights are extinguished, and that the fires are safe. He must be particularly careful to see that the wine-cellar is locked, and that the plate and valuables for which he is responsible are safely locked up for the night. If the master of the house has no valet, the butler may be called upon to perform some of his duties, but these will not be arduous, and need not interfere with the performance of his regular duties.

The butler must see that the wine-cellar is kept in a clean and proper condition. He should be familiar with the qualities and treatment of the various wines, and so be able to advise his master as to the best choice. The butler must know what is the proper treatment of the various wines under his care, and he should spare himself no pains in his endeavour to secure for his master the reputation of "keeping a good wine-cellar."

Although the wines are often purchased ready bottled, it is sometimes the butler's duty to fine and bottle them, in which case he should be familiar with the process. A portion of wine is drawn off from the cask, mixed with the white of four eggs, and thoroughly stirred. This mixture is then returned to the cask by the bunghole, together with the rest of the wine previously withdrawn. The contents of the cask must be stirred round by means of a wooden rod inserted through the bunghole. All bubbles rising to the top should be removed when the mixing is finished, the bunghole plugged, and the cask left to stand for three or four days. Wine so treated will fine 12 to 14 gallons of port or sherry.

Some butlers prefer other clearing ingredients than the white of eggs. Small pieces of isinglass or gelatine, cut into tiny fragments and dissolved in the withdrawn wine, may be used instead.

Bottling Wine. This is an important operation. A small hole is bored at the bottom of the cask, a gimlet being used for the purpose. The bottles are in turn placed under the hole and a strainer is used to prevent "grounds" from entering the bottle. As the cask becomes nearly empty a piece of muslin placed over the strainer will filter the wine more effectually.

The corks should be soaked in hot water and then squeezed dry. The bottle to be corked is placed in the bottling-boot, which is strapped on to the knee of the person doing the corking; the cork is then forced in with several smart blows from a broad, wooden mallet. The corks should then be sealed, or the heads of the bottles dipped into quicklime or petroleum, in order to keep insects away.

The bottles of wine should be carefully counted and a written record of them kept by the butler. By reference to this notebook the butler should know the exact contents of the wine-cellar and particulars as to when the wine was used The bottles of wine are laid on a wine-stand in layers. The alternate layers will be with either head or bottom of the bottles outwards, and between the layers there will be sawdust or straw.

The "Cellar-book." A careful butler will wash the empty wine-bottles and keep them carefully sorted. This is a great saving of trouble when bottling is in full swing. If the wine is purchased ready bottled, it will not be so necessary to keep the different kinds of bottles sorted, but whenever a fresh supply of wine is bought, the butler will do well to return a corresponding number of bottles to the merchant.

The casks should be well rinsed with boiling water and kept scrupulously clean. Should there be any trace of a sour or musty smell, the cask must be cleansed with lime and boiling water, and well rinsed and dried before being used again.

The butler should also keep a "cellar-book," in which to make a careful entry of every bottle of wine used. This book should be a complete record of all the wine drunk, and enable one to see the contents of the wine-cellar at a glance. In advising his master as to the ordering of fresh wines to replenish the wine-cellar, the butler should be careful not to allow himself to be influenced by bribes from wine merchants. These are occasionally offered, but a scrupulous butler will not allow himself to give way to temptations that are derogatory to his master's interest.

The Butler's Wages. The head-butler's wages vary considerably with different localities, ranging from £60 to £80 per annum. The under-butler's duty is to assist the butler in every way. He will carry up the wine and do the greater part of the cleaning and tidying of the wine-cellar, the washing of the wine-bottles, etc. If there is no under-butler, these duties will have to be performed by the butler, who will himself carry up the wines to the dining-room.

THE HOUSEKEEPER

The housekeeper must never allow herself to forget that she is the immediate representative of her mistress. She is responsible for the comfort of the servants working under her direction, and it is her duty to see that each domestic gets his or her meals at suitable times, and that these are served in a satisfactory manner. She must supervise the other conditions of the servants' also lives, seeing that each in turn gets reasonable time for rest, recreation, and exercise, and that the various duties are fairly apportioned.

Although the housekeeper's room is a sanctum in which butler, valet, and lady's-maid alone associate with the housekeeper, this room should not be far removed from the servants' hall and kitchen. It should be sufficiently near for the housekeeper to have every opportunity of seeing that all is satisfactory in these other rooms; but, on the other hand, it should not be so near

that the servants feel an uncomfortable sense of restraint. Servants dislike nothing so much as the idea that they are being "spied on," whether by mistress or housekeeper, and petty deceptions and deceit are more than likely to be bred by a system of espionage. A tactful housekeeper will make it evident that she is quite ready to detect wrongdoing or neglect of duty without making her attitude annoyingly aggressive. The ideal housekeeper should possess the same moral and mental gifts as those previously enumerated as desirable in a good mistress, and she should also endeavour to promote a good tone among the domestics of her household. Her punctuality should be unimpeachable; she should be neat and methodical in the execution of her duties, and her love of order and cleanliness should make itself felt in her organisation and control of the work of the household.

Accounts. The disposal of a considerable amount of money devolves upon the housekeeper, and she must keep a careful record of all money that passes through her hands. For this purpose she must be well skilled in the keeping of accounts and abl to extend her neatness and method to the keeping of certain books and records of expenditure. Her account-books should present a methodical register of the outlay of the household in current expenses, such as wages and tradespeople's bills. Every time money is spent its expenditure should be entered, and then the different items sorted out and re-entered under the various headings as food, wages, etc. The housekeeper will also find her expenditure easier to control if she keeps a record of all things ordered and received. She can compare this list with the accounts sent in by the various tradespeople, and so detect any attempts at fraud and overcharging. The housekeeper's accounts should be carefully kept and balanced by the master or mistress at stated intervals. This examination is most desirable and satisfactory to all parties concerned.

The housekeeper's salary will depend much on the conditions under which she is engaged, varying from about £20 to £50, or more in large households.

The Housekeeper's Duties. The housekeeper's duties vary considerably according to the size of the ménage which she has to superintend. If the household is large and she has a great number of domestics under her control, she will of necessity be kept very busy if she is to carry out her duties satisfactorily. She should rise early, and see that the early morning work is properly performed. She should also see that breakfast preparations are well made, so that the meal can be punctually and comfortably served at the appointed time. After breakfast she will be busy making various arrangements for the day.

She will have to superintend the orders sent to the various tradespeople, such orders always passing through her hands before they are sent off. She will then make a tour of inspection through the house, and see that the servants are all conscientiously performing their allotted tasks. She should be quick to notice where repairs are necessary—if cushion-covers and upholstered furniture need mending, if the windows are in good working order, and well cleaned, and that the furniture is not scratched or badly polished; in fact, a well-trained housekeeper is always on the alert, and no detail of housewifery or household management will escape her notice.

The Care of the Linen-press. One of the housekeeper's principal duties is to look after the stock of linen in the house. This will occupy a portion of more than one day in each week. An inventory should be made of the contents of the linen-press and the linen in use. A housekeeper should know how many tablecloths, sheets, etc., her stock should comprise, and she should systematically examine each set of articles with a view to ascertaining whether her stock needs replenishing. In many cases, by arranging for a little judicious darning and mending, the life of some articles may be much prolonged. The best time for a housekeeper to arrange for such replenishing of her stock of linen is during the summer. The ordinary household routine is then considerably lightened; there are no fires to tend, and the hours of daylight being lengthened, more work can be done without fatigue. The linen-press should be so carefully overhauled that the stock of linen is never allowed to get low, for directly the housekeeper notices that an article is wearing out, she should take steps to replace it. The same method should characterise the housekeeper's care of everything under her charge. She should at intervals make lists of all the different articles for which she is responsible, and by this means detect any loss or deficiency caused by breakage or wear.

The Store-cupboard. The care of the store-cupboard will occupy a good deal of the housekeeper's time, and she will do well to let each season add to her store of preserves or pickles. In very large establishments she will have little or nothing to do with the cooking, except to see that the kitchen arrangements are satisfactory, and that the meals are served punctually and well. In most cases, however, the housekeeper takes some share in the preparation of a few dainties and preserves. Thus she will perhaps be responsible for the dessert, and particularly for the sweetmeats, crystallised fruits, ginger, and salted almonds used at that course. During the summer and early autumn months she will find herself busy in assisting with the making of jams, jellies, and pickles of various kinds.

In the spring the housekeeper is responsible for the proper conduct of the spring cleaning. She should carefully supervise the turning-out of each room, and, with the sanction of her mistress, get rid of all unnecessary articles, which only serve to fill up the house and accumulate dirt and dust. She should notice carefully if any particular part of the house calls for the attention of the painter or paperhanger, and, if so, bring the matter before her mistress.

The housekeeper must take the greatest care

to preserve her own dignity and authority in her dealings with the servants of the household. To her lot will fall the task of engaging the women-servants, and she will, therefore, have to make all inquiries as to the character and previous experience of the servant making application for the situation. In doing so she should take the same precautions as those indicated in the earlier part of this section as being desirable for a mistress. In the exercise of her duties, the housekeeper should avoid all semblance of being overbearing and exacting, but she should never lose sight of the dignity and responsibility of her position.

THE VALET

The valet is, of course, the personal attendant of the master, and his duties chiefly consist in looking after his comfort and well-being. The valet has exceptional opportunities of showing his loyalty and zeal in serving his master. He must also possess no small amount of tact and patience, and be able to bear petty annoyances and retain his good temper and respectful manner, even on occasions when his master may be overbearing and irritating.

A good valet will always maintain a respectful demeanour, never allowing himself to lapse into undesirable familiarity. The valet must be absolutely trustworthy, since in his intimate dealings with his employer he has abundant opportunities of defrauding him. He should be very careful in his conversation in the housekeeper's room, and should never repeat any private family matter which has come to his notice, or which he may accidentally learn in his confidential position. In the matter of his own personal appearance, the valet should take pains to be neat and well-dressed. He never wears a livery, but he is, as a rule, the recipient of the clothes his master no longer cares to wear.

The Valet's Daily Routine. The valet's first duty will be to see that his master's dressing-room has been properly swept and dusted by the housemaid. Then, if the weather is cold, he should see that the fire is alight and well tended, and that the room has been properly aired. He should then put all his master's clothing in readiness. The linen and woollen garments should be well aired, and the suit carefully brushed and folded. Everything that his master will need for his toilet should be in readiness; soap, towels, and brushes should be in their proper places. The valet should also put hot water in readiness for washing and shaving, and see that the razors are ready for use. When the master does not shave himself, the valet must be competent to perform the operation.

This servant should also be skilled as a hair-dresser, since he will have to brush and arrange his master's hair, and should he possess beard or moustache, these must also be given attention. While the master is dressing, the valet should be in attendance, handing him in turn each article he requires, and adjusting his necktie, etc.

The valet will doubtless be required to perform various little commissions for his master, such as taking notes and messages. He must, however, find time to keep his master's wardrobe in good order, be careful of his master's appearance, see that his clothes are well brushed and all stains removed, and his silk hat ironed when necessary. He should also see that the master's toilet is irreproachable, and that all necessary repairs are executed. The valet should never allow his master's stock of underwear and smaller articles, such as socks, gloves, ties, collars, etc., to get very low, and should advise him in the matter of replenishing his wardrobe.

The Valet's Duties. During the absence of the master, the valet has not very many duties to perform; but he should be in readiness to wait on his master at all times, and particularly when dressing for dinner. After his master's toilet is completed, the valet should set his dressing-room in order. He should brush and put away discarded suits, and tidy the dressing-table, cleaning and setting in order razors, brushes, and comb, etc. Should he be in attendance on an elderly master, he may be required to give rather closer personal attendance, such as sleeping in an adjoining ante-chamber, accompanying his master out of doors, etc. He may also be required to wait at table, in which case he will stand behind his master's chair and confine his whole attention to administering to his wants.

Sometimes the valet is required to travel with his master. In this case he will doubtless be more or less responsible for looking out routes, taking the tickets, and securing a comfortable seat. Whenever there is a change of carriage or a long delay, the valet should seek his master's carriage, and wait on him. He may be required to get tea or newspapers, and he is also responsible for the luggage. He must see that it is properly labelled and put in the van, and keep his master's dressing-case, or bag, under his personal supervision in his own carriage.

Continued

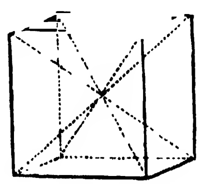
MINERALS IN THE EARTH'S CRUST

Determination of Minerals by Appearance, Properties, and Chemical Composition. Rocks are Built up of Minerals in the Earth's Crust

Continued from page 624.

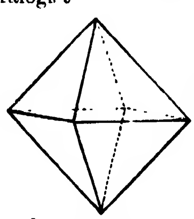
By W. E. GARRETT FISHER

Minerals Form Rocks. All rocks are made up of one or more minerals. In the case of a rock which—as is most common—has several mineral constituents, it is necessary to distinguish between the *essential* and the *accessory* minerals. An essential mineral is one which could not be removed from the rock without materially altering its character; thus, quartz is said to be an essential constituent of all granites, whereas the crystals of topaz and beryl, which often occur in granite, are accessory—their absence would not affect the granitic character of the rock. Again, we have to distinguish between *original* and *secondary* minerals. The original minerals are those which formed part of the rocks when they were first laid down, while the secondary ones have been added later, by chemical changes, or by the intrusion of water holding them in solution, or by similar methods. The veins of ore which are so important a part of the mineral resources of a country afford good examples of secondary minerals which have been introduced long after the formation of the rocks in which they occur.

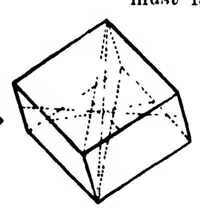


8. CUBE

The business of the mineralogist is, in the first instance, to be able to identify any specimen which is submitted to his examination, and to state the conditions under which it is likely to be found in association with other and perhaps more valued minerals. This part of his work, as will be obvious, is of great value to the miner, but it is possible or necessary to give here only a brief outline of the principles by which it is directed. In an elementary course of geology we need concern ourselves only with a small number of the existing minerals—those, namely, which chiefly compose the more common rocks of the earth's crust. The methods by which these minerals are identified, and their characteristics, can be learnt so simply in the laboratory and the museum that it would be a waste of time to give more than the briefest outline of them now.



9. OCTAHEDRON



10. RHOMBOHEDRON

Testing Minerals. Minerals are distinguished by (1) their external appearance, (2) their physical properties, (3) their chemical composition. Of course, the third of these tests is the most valid and satisfactory, and is always applied when the resources of a proper laboratory are at hand. But the practical geologist has to do the greater portion of his work in the field, with only the aid of such simple instruments and reagents as he can carry on his person. The prospector, who is searching for specimens of ore, is in the same position. Consequently, it is eminently necessary that he should be able to identify the more important minerals by means of the first and second tests—by their general appearance, supplemented by such physical properties as he can examine off-hand. To these he is able to add such chemical tests as can be applied by means of the simple apparatus and reagents which can be carried on a geological tour or added to the camp outfit of the prospector. By these methods the trained mineralogist can satisfactorily determine the nature of practically every specimen with which he is likely to meet, though here and there a puzzling mineral may have to be left for thorough inspection in a properly equipped laboratory.

There is no royal road to the power of identifying readily the more common minerals. The student must familiarise himself with their appearance by practice. He may usefully begin with one of the boxes containing fifty or a hundred typical specimens which are sold by most of the scientific instrument dealers, and then extend his research in the wider collection of a geological museum, such as that of the Geological Survey, in Jermyn Street, the Natural History Museum, in Cromwell Road, London, or in the collections attached to any of our provincial universities. The following outline will show him the main points for which to look.

Determination of Minerals—External Form and Structure. Minerals, though varying so widely in their outward appearance, can all be classified in this respect under one of four heads. They are (*a*) *Crystalline*, (*b*) *Vitreous*, (*c*) *Colloid*, (*d*) *Amorphous*.

Crystalline minerals are those which occur in the shape of regular geometrical solids, bounded by smooth, shining faces. A very large number of minerals are found in Nature in these forms. The phenomena of crystallisation is explained in the course on PHYSICS. It is enough here to remind the student that they always imply

that the substance which presents them has been solidified from a state of fusion or solution. It is a law of Nature that every substance which is susceptible of taking on a crystalline form adheres to it under all conditions and in all places where it is found—although it must be noted that many minerals have apparently more than one crystalline form, which they assume in accordance with the physical conditions under which they are deposited. Thus, calc-spar [12] (*carbonate of lime*, $Ca\ CO_3$) is found in nature under many crystalline forms, such as the familiar dog-tooth spar [11]; but each of these is reducible to what is known as the fundamental form of calc-spar, a rhombohedron [10]. The fundamental form of fluor-spar (*calcium fluoride*, $Ca\ F_2$) [15] is a cube [8], but it is found in many other forms, such as the regular octahedron [9], each of which is a modification of the cube by the slicing off of successive corners.

Crystallography. A crystal is a geometrical solid bounded by plane surfaces. These bounding surfaces are called the *faces* of the crystal. The lines in which they meet are called its *edges*, and the point where three or more edges meet is called an *angle*. The vitally important thing in the study of crystals is that these angles always remain the same in similar crystals. A crystal as it occurs in nature often looks very different from the trim figures of the text-book. It may have grown up under conditions which have truncated it in one direction and exaggerated it in others. But its angles always remain constant to the form to which it belongs, and by measuring them it can be assigned to its proper system with certainty. Consequently, the most important piece of apparatus used by the crystallographer is the *goniometer* (angle measure·), which enables him to measure the angles of any crystal with rapidity and care, either by directly laying two hinged arms fitted with a scale on the faces of the crystal (*contact goniometer*) or by measuring the deflection of a beam of light which is reflected from adjoining faces (*reflecting goniometer*).

After the angles of a crystal, the most important thing to examine is its *cleavage*. All crystals have the curious property of splitting more or less readily along planes which are called *cleavage planes*, and which in all cases are parallel to the faces of a fundamental form, or to the diagonals of a face. Some crystals, like dog-tooth spar [11], can be split along their cleavage planes by a mere tap; even the diamond, though the hardest of minerals, can be shaped by chipping away its corners along the planes of cleavage.

Classes of Crystals. There are 32 different classes of crystals, of which all but two or three are known to occur in nature. They are divided into six systems, of which the following typical examples may be examined in a museum:

System of Crystallisation	Example
(i) Anorthic	Axinite.
(ii) Monoclinic	Gypsum.
(iii) Orthorhombic	Barytes.
(iv) Hexagonal	Quartz, Calcite.
(v) Tetragonal	Zircon.
(vi) Cubic	Galena.

Enough has been said to indicate the importance of a knowledge of crystallography to the practical mineralogist. The great law of crystalline form tells us that bodies of the same chemical composition always crystallise in the same fundamental form, or in a form which can be reduced to it by simple cleavage, and conversely we know that crystals of a certain form must belong to one or other of a limited group of minerals. Often the crystal is so distinctive—like the diamond, ruby, or dog-tooth spar—that the mineral can at once be named. At any rate, we have a guide for the application of further tests.

Non-Crystalline Minerals. *Vitreous*, or glassy, minerals are easily recognisable. As their name indicates, they are a kind of natural glass, which may, or may not, be translucent. Obsidian [14], the well-known "volcanic glass," is a familiar example. These minerals have mostly been fused, as in the lava of a volcano, and have cooled too quickly for crystallisation to occur.

Colloid minerals consist of a substance which reminds the observer of a petrified jelly. Silica is the most abundant mineral which takes this form. Opal [13] is a hardened variety of it.

The rest of the minerals are called *amorphous*, or shapeless, because they assume no definite form, but are found in more or less coherent masses, tufts, or granules. The soapstone [16] used by tailors, under the name of French chalk, is a good example.

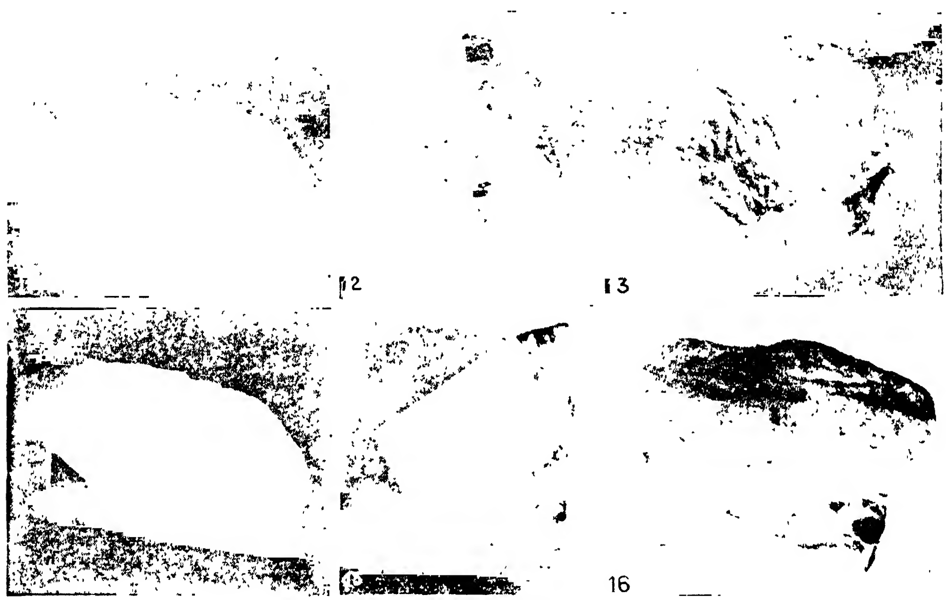
Physical Properties of Minerals. Every mineral has a distinctive set of physical properties which are of great service to the mineralogist in determining its place in the series of nature. First comes the *specific gravity* [see PHYSICS], or weight of a mineral, compared with that of an equal volume of water. This is tested by weighing the specimen first in air and then in water; but the practical geologist soon learns to make a rough but fairly accurate guess of the specific gravity by poising the specimen in his hand. Next comes the *hardness* of the specimen, measured in terms of a series of ten minerals ranging from talc up to diamond: the mineral is placed between the last which it will scratch, and the first which will scratch it. The *colour* of the mineral and of the *streak* which it leaves on paper, or which a knife leaves on it, its *lustre* and *transparency*, are also noted. The nature of its *fracture* when broken is important. It may have a characteristic *taste* or *odour*. Lastly, its *optical*, *electrical*, and *magnetic* properties have to be observed; but this usually involves the possession of apparatus, such as

the polariscope and the electrometer, which cannot be taken into the field, and belong to the mineralogical laboratory rather than to the camp outfit.

Chemical Composition of Minerals. The only absolutely satisfactory test of a mineral is that afforded by a complete chemical analysis, which can, of course, be carried out only in a properly equipped laboratory. A few rough tests, indeed, may be applied in the field, such as the use of an acid to see if a carbonate is present, when a little carbon dioxide (CO_2) is given off with visible effervescence. Beyond these simple tests, the business must be learnt by practice, and the average geologist is content to depute it to the chemist.

Large masses of such visitants are still lying on the soil of Greenland and Arizona. Carbon occurs uncombined in two forms—as *graphite*, or *plumbago*, which, from its property of producing a black streak on paper, is utilised in the manufacture of the so-called lead pencil; and as the most splendid of gems, the diamond, which is simply a crystalline form of pure carbon. Sulphur is also found native, as a product of volcanic action: the Spanish conquistadores obtained the sulphur for their gunpowder from the crater of a volcano.

Oxides. Certain *Oxides*, or compounds of oxygen in another element, form important constituents of the rocks. The two which we need to note here are the oxides of silicon and iron.



TYPICAL MINERALS

11. Dog-tooth spar (Matlock, Derbyshire). **12.** Calc-spar (Cumberland). **13.** Opal (Hungary). **14.** Obsidian (Lipari Isles). **15.** Fluor-spar (Cumberland). **16.** Soapstone (North Carolina)

Classification of Minerals. Minerals have been classified in various ways, but the most satisfactory system, on the whole, is that which depends on chemical composition. We shall be content to glance briefly at the twenty or thirty more important minerals which chiefly go to build up the rocks of the earth's crust. These leading minerals may be classified for convenience according to their composition under various heads—to understand which some knowledge of elementary chemistry, such as can be obtained from the course on the subject, must be assumed.

Native Elements. Certain *native elements* occur as minerals. Gold, copper, and iron are found in small quantities in the metallic form. There is reason to believe that most of the native iron found as a terrestrial mineral reached our planet in the form of meteorites.

Silica ($Si\ O_2$) is a compound of silicon and oxygen, which is best known in the form of the ubiquitous and beautiful mineral known as *quartz*. It is crystalline—indeed, the Greeks called it "crystal," and held it to be petrified ice—and its fundamental form is that of a six-sided prism. But there are innumerable varieties of silica, which is the most abundant of all minerals. Some of these, like amethyst and catseye, are so beautiful as to be regarded as precious stones. Other forms of silica are chalcedony, opal, onyx and agate. Flint, on which the beginnings of human civilisation depended, is also almost pure silica, which has grown into nodules in the chalk-beds.

Iron oxides play a great part in our scenery. *Hæmatite* ($Fe_2\ O_3$), is the red oxide of iron which colours so many of our rocks—*e.g.*, red sandstone and clay (red ochre). It occurs very

abundantly, and is largely worked in the Lake Superior mines and in Cumberland. *Limonite* ($2\ Fe_2\ O_3 + 3\ H_2\ O$), or brown iron-ore, is a hydrated oxide of iron which has been largely deposited from chalybeate springs, as yellow ochre, or bog iron-ore. *Magnetite* ($Fe_3\ O_4$) is the magnetic iron oxide which was early known as the lodestone, from its remarkable property of attracting iron and of causing a needle rubbed with it to point to the north—the mariner's compass. Vast deposits of it occur in Scandinavia, and it is one of the main sources of the world's iron supply.

Corundum ($Al_2\ O_3$) is an oxide of aluminium which may be mentioned (although it does not occur largely in nature) because two of its varieties are the ruby and the sapphire, whilst in the less precious form of emery it gives us a valuable polishing material.

Silicates. The *Silicates*—compounds of silica, or silicic acid, with various metallic oxides—constitute by far the most important group of minerals. "By themselves they constitute at least nine-tenths of the terrestrial crust, and make up practically all the rocks, except the sandstones, quartzites and carbonates." (Geikie).

The *Felspars* are composed of silicate of aluminium, combined in varying quantities with the silicates of potassium, sodium, and calcium, with traces of magnesia and iron oxide. They vary in character according to their composition. The most typical felspar is *Orthoclase*, or potash felspar ($K\ Al\ Si_3\ O_8$). It is an abundant constituent of granite. *Albite* ($Na\ Al\ Si_3\ O_8$) is the corresponding soda felspar, and *Anorthite* ($Ca\ Al_2\ Si_2\ O_8$) is a lime felspar. There are numerous other felspars of varying but generally similar composition. The group is often divided by the cleavage of its crystals into *orthoclase*, with cleavage at right angles; *plagioclase*, with cleavage at an acute angle, and *oligoclase*, with ill-defined cleavage.

Next comes the *Mica* group of silicates. All these minerals share the well-known property of common mica—that they can easily be separated into thin flakes, or *laminæ*. *Muscovite* is the common mica—of which lamp-shades and furnace-windows are made—so called because it comes from Russia, and was once known as "Muscovy glass." It is a silicate of aluminium and potassium of which no exact formula can be given as its proportions vary considerably. *Biotite* is another mica, differing in the presence of magnesium. The glittering flakes of mica are nearly always visible in granite.

The third group of silicates is that represented by *Hornblende* and *Augite*, which are bisilicates of calcium, magnesium, iron, and manganese. These two minerals are closely related, and play a considerable part in the constitution of the granitic and volcanic rocks. Allied to them are *Diallage* and *Hypersthene*. *Olivine* is a silicate of magnesium, iron, and manganese, which forms an essential ingredient of *basalt*.

The fourth group contains *Talc*—the well-known soapy mineral—and *Chlorite*, which are hydrated silicates of magnesium. *Serpentine* is of similar composition, with the addition of aluminium and iron. It is harder, but can still be cut with a knife, and gets its name from the beautiful mottling of its brown and green surface.

Carbonates. A large proportion of the rocks which form the earth's crust are composed of *carbonates*, or compounds of certain metals with carbonic acid, the gas which is produced by combustion or breathing. [See CHEMISTRY.] The most important of these is the carbonate of calcium, which occurs in nature in two forms, alike in chemical composition but differing in external appearance and physical properties. *Calcite* ($CaCO_3$), or calc-spar, is the essential basis of the great masses of limestone rock which are so abundant in many parts of the world, as in Derbyshire. It crystallises in the fundamental form of the rhombohedron. A particular variety which has become famous by its optical properties is the doubly refracting Iceland spar, which gives a twofold image of all objects seen through a transparent slice of it. *Aragonite* ($CaCO_3$) is a harder and more durable form of calcium carbonate, which is much less abundant than calcite, and occurs in rhombic crystals. *Bitterspar* ($CaMgCO_3$) is a double carbonate of calcium and magnesium, found in greatly varying proportions of the two metals, which is chiefly interesting as the basis of the Dolomite rocks which form the great mountain masses of magnesian limestone in the Tyrol and Carinthian Alps. *Siderite* ($FeCO_3$), or brown ironstone, is a carbonate of iron often found in nodules in shaly beds.

Sulphates, Sulphides, Fluorides, Chlorides, Phosphates. The remaining minerals which, in smaller quantities, help to build up the rocks of the earth's crust, call for only brief mention here. Sulphate of calcium is found in two shapes, *Anhydrite* ($CaSO_4$) and the well-known *Gypsum* ($CaSO_4 + 2H_2O$). Sulphate of barium is barytes ($BaSO_4$), known from its heavy weight as *Heavy Spar*, which is often found in association with metal ores. Sulphides of various metals (lead, silver, copper, zinc) are of great commercial importance, but the only one which the geologist need consider is iron sulphide, which occurs as *Pyrite* (FeS_2), the familiar *Iron Pyrites* or "fool's gold," which ignorant prospectors often mistake for a valuable source of the precious metal, and as *Marcasite* (FeS_2) which plays a large part in the decomposition of rocks by its power of producing sulphuric acid on exposure to damp air. There are only two important compounds of the haloid elements found as minerals. Sodium chloride, or *common salt* ($NaCl$), is found in vast beds at places like Nantwich, where it is of great commercial importance. Calcium fluoride is the beautiful *Fluor-spar* (CaF_2) **[15]** used, from its property of giving off fluoric acid when treated with an acid by the glass etcher. Lastly, one may mention *tricalcium phosphate* or *Apatite*, which occurs in Norway and elsewhere, and has great importance to the agriculturist from its use as a fertiliser.

Continued

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A NEW FIELD FOR LOCAL TRADE

"Back to the Land" with Trade. The Commercial Possibilities of Rural England. Food Supply of the Village. The Motor Van as Distributor

By ERNEST A. BRYANT

"BACK to the land" is now a popular cry, a cry which, it is to be hoped, will become still more popular. Specialists show in other courses in the SELF-EDUCATOR how profitable it may prove to the men in overcrowded towns to go back to the land, and how those already on the land may better their positions. New ideas and new processes are as desirable for agriculture as for any other industry which employs a considerable number of men. At present, however, we concern ourselves only with the life of the villager and the affairs of his tradespeople.

Assuming that a certain proportion of the men now seeking in the markets for employment where no employment is—assuming that a certain proportion of these do go back to the land, what is their prospect in the village? It might be thought that, so far as the domestic economy of the home is concerned, all that man and his wife desire must be available; that in an agricultural and fruit-growing district there will be abundance of cheap fruit and vegetables, eggs, milk, and cream. The opposite is the case. We refer mainly, of course, to villages whence London may readily be reached by rail or cart. The same conditions apply, in a lesser degree, in the villages of which the great provincial cities are the centre. There is no local trading.

A Limited Market. The money of his neighbour does not appear to possess any value for the grower of agricultural produce. Unless his fruit and vegetables go to Covent Garden, or his milk, cream, and eggs to the big dairies of the metropolis or lesser centres, he does not, apparently, find any satisfaction for his labours. The consequence is that the average villager is worse off for the bare necessities of life than the man who herds with the million in crowded city areas. Take strawberries, for example. The cost of these to the consumer, if he buy them in the heart of the district in which they are grown, is 50 per cent. more than if he had got them in town. The grower has to pay railway charges, and then sell at such a price as to yield profit to the Covent Garden merchant, then, perhaps, to a middleman, and finally to the retailer. If he gets a penny or three-halfpence per pound for his crop he is a fortunate man. Yet the same man is not anxious to sell his fruit privately at less than sixpence per pound where it is grown, though London retail rates at the time may be 50 per cent. lower.

Wasted Food. The same rule applies to vegetables. As soon as they are grown they are carted, or sent by rail, to London, to take their chance in a market which may, or may not, be over-stocked. On the spot where they are grown it is a favour to be able to purchase any at much more than the Covent Garden tariff. Milk has the same fate. There is no place in which it is so scarce as in the country. Farmers give thousands of gallons of separated milk to their pigs rather than sell it. Only in the country is it necessary to give several days' notice if cream be wanted. It pays foreign firms to send over commercial representatives to exploit cream and butter. Both go into villages, and are, therefore, bought by villagers whose local milk and cream supply goes all to London at absurdly low prices. There seems to be a universal tradition that you shall not buy in a given place that which forms the staple industry of such place. Nobody buys lace at Nottingham, or cutlery at Sheffield; nobody ever bought locally-made calico at Bolton, Bury, or Blackburn.

The Purchasing Power of Money. All this is discouraging to the man who has gone back to the land. He finds in the season when eggs are most plentiful that they cost him more than the London resident must pay; that the milk with which he is supplied is not of as good quality as that sent to London—the cream is conspicuous by its absence; all kinds of fruit are scarce and dear. He is in the midst of plenty, but it is not for him. He must live, hence he must eat. He must buy his produce at the shop which has obtained its hamper of potatoes or other vegetables, not from the surrounding fields, but from the middleman, who has purchased from Covent Garden or some correspondingly central depot. He may actually find that his wages have less purchasing power in the country than in a city where competition is keen and tradesmen satisfied with small profits from quick returns. If he ventures to use gas as an illuminant, he inevitably pays a higher rate than the townsman; his meat, perhaps, is more expensive; boots, clothes, coal—everything costs more. Where, then, is the advantage of returning to the land?

What the Villages Need. All these conditions, it must be repeated, apply chiefly to villages adjacent to London and other great towns and cities; in places more remote, the circumstances are necessarily modified. There is room for considerable development in village trade. The rural districts want good stores. Some have them already, establishments whose stocks are miracles of comprehensiveness. But these are the places that sell foreign cream when the local supply is sent away by train to fetch starvation prices. These are places at which are sold American and other foreign apples, while in the orchards around them English fruit is rotting on the trees. These are the places at which are sold

cheese from Holland and America, while that made in the village is allowed to bear the cost of cartage and railway to the markets of the cities.

We want new stores or developments in old stores. That money is to be made from the stores conducted even on the present lines is manifest from the fact that private companies here and there control series of them in adjoining villages. But the time has come for a distinct advance upon the old methods. The villages ought to have a regular service of goods by motor-van. One of these, starting in the morning from some central depot, would serve in the course of the day village after village. It would dispose of its wares either to shops or stores, or at the houses of individual customers.

A carrier manages to keep a couple of vans and four or five horses by carrying to and from the market towns such small bulk or wares as he is able to manage. His efforts, however, in comparison with the possibilities of the motor-van, are as those of the old coach proprietor contrasted with a first-class railway.

The motor-van runs at very few pence per mile and in the course of a day can cover a vast area. It could supply everything needed upon its round, conferring a boon upon the villages and bringing a solid profit to its proprietors.

The Village Trader's Opportunity. In the towns competition between traders is already so keen as often to reduce profits to vanishing point. Within a few miles of such towns is virgin soil, with crops of custom, so to speak, ready to the hand of the man who has a disposition to reap. For the prosperity of those already on the spot, it is, of course, desirable that they themselves should take the lead.

There is no reason why they should not. Every village trader knows that his neighbours are compelled every week to go into the nearest town to buy goods which he cannot secure locally. That means the outlay on the part of the purchaser of money in fares which might otherwise be devoted to additional purchases. With the motor-van regularly plying there would be no excuse for the village stores not keeping stocks as representative and up-to-date as those of rivals a dozen miles away in the town. Money which now goes unnecessarily into the cities would thus be kept in the country areas. It needs no argument to demonstrate that the greater the amount of money available, the greater the possibilities for the district. We would not, of course, have it appear that the motor-van is to be regarded as the embodiment of all efficacy; but it is undoubtedly a means to a desirable end. With facilities in this manner multiplied, there is the greater inducement for substantial business men to go farther afield; to set up house in the country and spend money there for the advantage of the whole community—their own not excepted. At present the "shopping" problem is a serious one. The housewife, accustomed to dealing with large establishments in London, finds her country home in what proves practically barren land. She cannot purchase what she needs in the village. If she sends to town for household requirements, she has to trust to the railway, and, as likely as not, her perishables will reach her several days late, and spoilt.

A Library for Every Village. Another item of the village problem, which at first sight may seem insignificant, has really an important bearing. The intellectual needs of the villager deserve attention. At present, life in many a rural centre in England is as dreary, monotonous, and unenlivened by any healthy recreation as if such village were in the heart of Russia. Men and women pass weeks and months without seeing a book or paper. After the day of toil, there is nothing for the cottager but to sit through the long, dark evening with nothing to deflect his attention from the sad monotony of his unlovely lot. Either he must sit and brood or—go to the public-house. Every village has its inn; how few possess a library! Granted, every rural authority has the power to establish a public library out of the rates. But to the mind of the villager this is too ambitious an undertaking; he would as readily avail himself of the right to light his dark lanes, or erect public baths and washhouses.

This blank in the lives of the village poor could be profitably filled by resident storekeepers. Every store in every village might have its little circulating library. Books are cheap and readily to be had. They can be bought new for far less than the formidable figures in the publishers' lists suggest. They can be bought cheaper still at the auction mart. By the expenditure of a few shillings it is possible to buy great bundles of classified second-hand books—novels, history, travel, biography, and more or less modern text books. These do not represent the pick of the literary basket, it is true, but any book which a man is not ashamed to put upon his shelves is better than no book. The main point is to get a start.

The Village Book-shop. It should not be a difficult arithmetical problem for the purchaser to determine what rate he must impose for the hire of his books. The smaller the price at which he can afford to lend a work, the better will be his prospects of increasing his connection. Books which have cost at auction a few pence might yield hundreds per cent. profit. The gain would come only in pence, it is true, but that is the sum in which the village merchant has chiefly to be content to count his results. Old magazines are to be had at waste-paper price and are often just as good reading a year after the date of issue as upon the day they leave the press. These afford scope for the man with the little lending library. [See Libraries.] The opportunity to devote an hour or two at night to wholesome reading is a greater boon to the man far from books than can be realised by those who live in close proximity to the libraries and newspaper offices of the towns.

It may be that with knowledge enlarged by

reading, the rustic may feel the more anxious to enter the town. But that is a difficulty which will always have to be faced. The man who is fittest for town employment will get town employment. On the other hand, the thoughtful person will be the more contented with his lot if he has at his hand some of the amenities of the life of the town against whose lure he is striving.

Skilled Nursing in the Village. A consideration for girls and young women which, with the passage of time, will become increasingly important is the scope for village nursing. Every village throughout the land is to have its trained, certificated nurse. At present there are not nearly sufficient nurses to meet the demand. All who have had experience of the country will know of places where for miles there is neither doctor nor nurse. Hundreds of young women are now taking up nursing as a profession. [See Nursing.] Too many of them do not look beyond the walls of the great hospitals in the towns. The villages offer excellent openings, as well for the practice of midwifery as for the general routine of the sick-room. It may savour rather of the fanciful to suggest that the villages should have their dentists. The average man is but now awaking to the urgent necessity for maintaining his teeth in a healthy condition. There is no reason why the qualified man, who is now content to drag out a miserable existence as an underpaid assistant in town, should not build up a practice for himself in the country. He must be prepared to do his extractions and fillings cheaply; but he can make a living out of his work, and a living in far greater comfort than the overcrowded condition of his market in town permits.

Everything which more nearly approximates the possibilities of the village to the facilities of the town makes for a solution of the problem of the congested labour market of the urban areas. Men and women who have lived in towns may be persuaded to go back to the land, but they will with less persuasion go back from it after an experience of the manifold disabilities which now exist in too many places. Inferior food at high prices, the absence of all avenues for intellectual exercise, the lack of all the amenities of everyday life are tolerable only to those bred to the conditions, and who have had no opportunity of contrasting them with other and better. Nowadays it is too often the case that men go from the towns into the country to die. Country life is stagnant, colourless. To it there might be brought the infinite variety and change of town life without in the least destroying the inherent charm of residence far from the madding crowd.

Handicapping the Countryman. It is too absurd that if your stove suddenly goes wrong, the local ironmonger, having waited three weeks for the part necessary to effect repairs, finds that his order must be transferred to a foundry in Scotland, then wait another three weeks, and finally receive something for which he is compelled to pay, although it is not of the slightest use to himself or to his patron. The countryman should not have to go to the market; the market should send its wares to him.

With projects such as these carried out, the village, while not sacrificing one whit of its rusticity, might become a real factor in the industry of that part of the country to which it belongs. The storekeeper should be able to deal with local growers of produce on terms as advantageous as those accorded to the autocrat of the market. The local fruit-grower, finding that he could command a steady sale in his own neighbourhood, would speedily see the wisdom of accepting a certain price for his goods in the local market in preference to sending all to town on the off-chance of a profitable sale. He would see the folly of charging in his own village 1½d. each for eggs the like of which he would have to sell at about 14 a 1s. in London, after paying the cost of carriage; he would realise that a good price for his fruit sold in the country is worth more than the smaller price gained at Covent Garden; the cowkeeper would understand that village money paid for village milk, cream, butter, and cheese, has just as great purchasing power as that which comes from town, even if it lack the halo of romance with which the latter appears to be invested.

Village Problems. To the student of rural life many other considerations conducive to the betterment of the villagers' condition will present themselves. The importance of arousing the public spirit of the rustic community must be manifest to all who interest themselves in this phase of our national life. When there comes the quickening of this spirit, the voice of the villager will be raised to insist upon the provision of habitable dwellings in which families may reside in decency and in health. The builder will find it to his advantage to meet that demand. Nowadays it is not uncommon to find people herded together in country cottages in a manner which would constitute a scandal if it were discovered in the slums of the cities.

The villages have their housing problem in as acute form as the greater hives of population. They have their difficulties as to drainage, water supply, and general health conditions. Until we see the countryman roused to a sense of his right to a healthy environment, to sanitary conditions of irreproachable character, and to a water supply of unimpeachable purity, the villages must still lack attractiveness.

There is in these unambitious schemes that which in the aggregate represents much to life and labour in the country. Until they are carried out the trend of the many will continue from the land into the already overcrowded towns. The accomplishment of such plans as these may go far to settle the "back to the land" problem by a simple process. Those already in possession will find their lot too pleasant to leave, while eligible hands from the overstocked labour markets of the towns will be only too glad to return.

Continued

Group 15
HISTORY

THE GOLDEN AGE OF GREECE

Continued from page 668

Victory of Marathon. The Persian Invasion. Formation of the First Great Fleet. Themistocles. Pericles. The Life and Conquests of Philip of Macedon

By JUSTIN McCARTHY

THE Athenians showed themselves the most vigorous and the most closely united in resistance to the Persian invasion, and under the leadership of Miltiades won by their own efforts the victory of Marathon. Miltiades had been chosen one of ten generals entrusted with the defence of Greece.

It was his resolute policy to risk a battle at once, and he won a complete victory. Marathon has been fairly described as one of the decisive battles of the world. It made Greece for the first time into a distinct and consolidated nationality.

A Greek Warrior. The career of Miltiades was not destined to be one of complete success. He was commissioned to undertake the conquest of the Cyclades Islands, but his attack upon Paros, one of the islands, proved a failure. On his return to Athens he was charged with treason to the state in not having faithfully followed his instructions. It was alleged that his having chosen the island of Paros for his first attack was owing to his desire to gratify some personal hostility, and he was condemned to pay a heavy fine. Miltiades was unable to pay this fine, and he was therefore thrown into prison. He had received a severe wound in the attack on Paros, and the effects of the wound, added to the troubles of his trial and imprisonment, ended in his death.

A more melancholy close to a career which had so splendid an opening has seldom been recorded in any history. That was not the only example of the kind which we find in the records of Greece. The fact that the Grecian states were made up to a large extent of regions which had, from the dawn of their growth, no nationality or fellowship, but were brought into union by common dangers, or by common ambitions calling for combination at some particular moment, may account for some of the distressing incidents which we find recorded in the story of the race. Each of the allied forces had its own local sentiments and favouritisms and jealousies, and the failure of a leader in any one attempt was sure to make him the object of condemnation, and often of combined hostility, among the peoples or the clans who were not themselves in full sympathy with his leadership. Indeed, the invasion of Greece by the Persians was provoked, in the first instance, by one of the invading expeditions of the Greeks themselves.

Persian Invasion of Greece. In the opening of the Persian invasion Thrace and Macedonia were conquered by the invaders, and it was by the efforts of Athens and Sparta in the first instance that the Persians were wholly defeated. It may well have been that among the leaders of those who had failed to drive back the Persians there was a feeling of jealousy and rancour against him whom Athens had been mainly instrumental in placing at the head of a combined army, the more especially as Miltiades had come from a Thrasian colony.

The Persians were not so far discouraged by their defeat at Marathon as to give up all idea of restoring their warlike renown and their hopes of subduing Greece. The Persians were in those days an essentially warlike race, and seemed to be fired by an irrepressible desire to extend their conquests over as much of the world as was then known to them. The failure of one expedition only provoked the formation of another. Not many years after, Xerxes I., who succeeded his father Darius as King of Persia, prepared for another great expedition against Greece. He formed a large army drawn from all regions under his rule, and, what will interest the modern reader still more, he actually formed a great fleet.

The First Fleet. The formation of a regular fleet for war purposes was a marvellous achievement in those days. It is stated that Xerxes' fleet numbered at least 1,200 vessels, and that his invading army from first to last had more than a million of men. To make his way into Greece more easy he threw a bridge across the Dardanelles, and had a great canal dug in order to save his fleet the perilous necessity of sailing round the promontory of Athos. Fleets and armies made but slow progress in those days, and we are told that the passing of boats across the bridge occupied seven days and nights. Xerxes poured his forces into Thrace, Macedonia, and Thessaly, and these provinces or states made no effort to resist, but allowed themselves, for the time at least, to surrender to the invading power.

Sparta, however, acted in a very different spirit, and made for herself an unfading record in the history of the world. Leonidas, the King of Sparta, waited his time, and when the Persians were about to penetrate the narrow pass of Thermopylæ, in Northern Greece, Leonidas, with a force of 300 Spartans and 700 Thessalonians, resisted the whole army of the Persians for three days. Then Ephialtes, a traitor to the Greek cause, conducted the enemy, or at least a large part of their force, by a secret path through the mountains, and brought them to the rear of the Spartans, who thus, with enemies in front and enemies behind, had nothing left but to fight to the last. They met their death nobly amid slain masses of their enemies. Only one

Greek was able to escape and to return to his home, and he was received by his countrymen with reproach and contempt for having left his comrades and saved his own life. Simonides, the famous Greek lyric poet, wrote an elegy on the dead Greeks who perished at Thermopylæ in which, speaking, as it were, from the lips of one of the dying heroes, he used the thrilling words:

> Stranger, let Sparta know her sons could die
> Obedient to her laws; for here our bodies lie.

Themistocles. The next great struggle between the Greeks and the Persians was a sea fight in the Gulf of Salamis, near Athens, 480 B.C. Themistocles, a great Athenian statesman and soldier, who had already accomplished much by prevailing upon his countrymen to see that a powerful fleet was needed to maintain anything like a successful resistance to their invaders, won a brilliant victory over the Persians—a victory which has been celebrated and, indeed, consecrated by unnumbered poets, historians, and artists of all kinds from that day to this.

Themistocles was actually, although not nominally, in command of the Athenian squadron, that squadron making much the larger part of the combined fleets of Athens and Sparta. The Spartan commander had not been inclined to await the attack of the powerful Persians, and Themistocles had to use all his influence indeed to employ some stratagem in order that the struggle might take place at once.

Themistocles became after this victory one of the most powerful men in Greece, but his power over his countrymen did not last, and his story is one of the too numerous illustrations of the manner in which during those days of early Greece the hero of one season has been the outlaw of the next. Sparta was jealous of Themistocles and his success, and the Spartan faction was still strong in Athens. The Spartans did all they could to effect his ruin, and it must be owned that Themistocles sometimes endeavoured to maintain himself by plots and stratagems which do not seem to have been quite consistent with pure patriotism.

His enemies prevailed against him, and he was sent into exile—at least, he was banished from Athens. It was generally believed that the hostility of the Spartans had for its principal cause the fact that he had advised the rebuilding of the walls of Athens on a much larger scale, and with far stronger materials than before; and that leading Spartans had assumed that this must be a project undertaken with the object of preventing Sparta from ever becoming mistress of the Athenian capital.

End of Themistocles. Themistocles, after his ostracism, or banishment, was removed from one place to another, until at last he fled into Asia, and was received there with cordiality and protection by the then reigning Artaxerxes. He seems to have acquired much influence over the Persian sovereign, and his enemies in his own country did not hesitate to say that he was at one time engaged in concerting with Artaxerxes plans for the subjugation of Greece. He died in Persia some 450 years B.C. Even concerning the manner of his death there was much controversy, for there was a theory accepted by many in Greece that he died by his own hand. The great English historian George Grote describes Themistocles as "alike vast in his abilities and unscrupulous in his morality."

During all these struggles with Persia Athens was becoming stronger and stronger. She had risen to be the leading state in Greece. She had won the chief honours in the war. She had accepted the position of leader in the struggle against Persia, and in the greatest triumphs over the Persian invaders she had won the best of the fame.

Cimon of Athens. Besides the heroes mentioned, Athens had sent into the war Cimon, the son of Miltiades. Cimon was both soldier and sailor; he had encountered the Persians at sea and completely destroyed one of their great fleets, and he encountered them on land with equal success. His military career closed with splendid victory, and brought the Persian War to an end. His life was not without its troubles. During the internal quarrels going on between Athens and Sparta, quarrels which he sought to bring to an end by establishing a friendly and complete alliance between the two states, he was accused by some among his own people of being an accomplice in the projects of Sparta, and for a time he underwent ostracism. He was recalled, however, to his former place in the confidence of the Athenians, and helped in obtaining an armistice of five years, if he could not obtain an actual alliance, with Sparta. After his restoration to power, he was again put in command of a fleet, and he died while engaged in an attack upon a hostile city. It is believed that Cimon did not find the manner of death which he would himself have chosen. There can be no question that, if he could have dictated terms to destiny, he would have elected to die in a gallant fight by some hostile sword; but the accepted belief is that he perished by an ordinary illness.

The Power of Athens. Athens now began to be the leading power in Greece. The Persian invasion had found Sparta at the head of the Greek peoples, but she did not long maintain this position after the struggle with Persia had fairly begun. Athens appears to have acted throughout the whole of the war with a steady and patriotic regard to the common interests of the whole Greek race, while Sparta would seem to have ever had in mind the maintenance of her own superior position. The Athenian commanders, too, proved to be men of the highest military and naval capacity, and in this way drew upon themselves the admiration of all the Greek peoples. The most signal victories over the Persians were won by Athens, and thus she came to be, for the time, the queen among the Greek states.

It was not to be expected that under the conditions then prevailing this supremacy should be long allowed to remain unchallenged by Sparta. The rivalry had yet to be illustrated by a long and severe struggle. Sparta made every effort to persuade the other Greek peoples that Athens was deliberately planning to obtain

the sovereignty of the whole country, and appealed to the patriotism of other Greek states in order to secure their help towards the repression of Athenian ambition.

Influence of Pericles. The leading man among the Athenians at this time was the illustrious Pericles. Pericles was born of an eminent Athenian family during the earlier part of the fifth century B.C., and had risen rapidly in public life as a leader of the democracy. In the struggles between Athens and Sparta, Athens represented the democratic, and Sparta the aristocratic, element in the modern acceptation of these terms. Pericles looked with utter disapproval on the rivalries and jealousies among the Greek peoples, and he was ever striving to realise a project of his for the creation of a great federation in Greece which might bring the peoples into fraternity under some system of authority representing all the different states.

Sparta set herself resolutely against this project, and for the time it came to nothing. Athens and Sparta were already beginning to drift towards that great international struggle which made so deep an imprint on the history of Greece. The climax of the rivalry was postponed for a time by an arrangement of a thirty years' peace between Sparta and Athens, and in the meanwhile the influence of Pericles grew greater with every day.

The age of Pericles may be described as the greatest age of Athens, the greatest age of Greece, indeed, one of the greatest ages in the world's history. Pericles was statesman, soldier, commander of armies and fleets, a lover and patron of arts and letters, and to him Athens owes some of her noblest architectural monuments. The traveller from foreign countries still gazes with enthusiasm and with reverence on the majestic Parthenon, than which the genius of architecture, inspired by lofty ideas and pious emotion, has never bequeathed to the world a nobler or more lasting trophy.

Athens had then but lately lost Æschylus, one of the greatest dramatists of all time. She still had Sophocles and Euripides, tragic poets who stand in equal rank; Herodotus the historian; Aristophanes, unsurpassed as a comic and satiric dramatist; Phidias, its most renowned artist; and Socrates, who holds one of the highest places among the great thinkers and interpreters of thought in the ancient and modern world. It is not surprising that under such conditions men from all parts of Greece, and from all parts of the world then within touch of Greek civilisation, should have streamed into Athens as into a sacred city.

Macedon. We need not enter into a minute survey of the various struggles between Athens and the other Greek states. These struggles gave opportunity in one way or another for the development of the genius of such men as Alcibiades and Epaminondas and Pelopidas, and of Xenophon, at once soldier, historian, and essayist. Xenophon was the son of a distinguished Athenian officer, and during all his earlier years, up to his manhood, he had been under the close and enlightened influence of Socrates, the greatest of Greek philosophers. Xenophon became commander in the march of the famous Ten Thousand, the history of which he has left to the world in his "Anabasis." He wrote many other books, the most interesting among which tell us all that he knew of Socrates. But in the meanwhile troubles of the most serious kind were awaiting the Athenians and the Greeks in general by the rise of Philip of Macedon. Macedon was a kingdom in the north of Greece which had been at different times under the protection of Athens, of Thebes, and of Sparta, had been conquered by the Persians, and redeemed by the Greek victory of Platæa. Macedonia had kings of its own, and of these Philip II. was the first to make a permanent mark on history. Philip was the third son of Amyntas II., King of Macedonia, and seemed at one time to have no chance of ascending the throne. His eldest brother was assassinated, and his second brother was killed in battle. The death of his father left to him the guardianship of his eldest brother's infant son. Philip was a man of daring ambition, and in a short time he contrived to make himself sovereign of the kingdom.

Philip II. It was not unusual in those days, where a Royal Family existed, for the leading men of a state to select any one actually of the Royal Family to fill a vacancy in the throne. In this way Philip II. was able to make himself King of Macedon. His kingdom was threatened with many dangers from other states, but his energy and ability succeeded in making the frontiers of his realm secure against invasion, and his restless spirit then began to occupy itself in enterprises of conquest. He captured a city in Thrace to which he gave the name Philippi, a place afterwards famous in the history of Rome, and associated since the days of Christianity with the teachings of St. Paul. There were gold mines in the surrounding regions which gave Philip ample means of paying his military recruits and extending their numbers, also of buying up supporters and accomplices among the populations he designed to make his vassals. He built a navy and greatly strengthened his army.

A Prison and a Kingdom. Macedon had been a kingdom from the earliest days of which we know anything, but had played a poor figure in the progress of Greece. An event which at first seemed a calamity in the early life of Philip had given him a singular opportunity of cultivating his genius and seeing how great deeds were to be done. He had been sent to Thebes as a hostage, and while there had been received into the house of Epaminondas, and had learned from the example of that great soldier and statesman some lessons in the art of war and in statecraft which he afterwards turned to account. Thus it was that when he became King of Macedon he was already well prepared for the career of conquest and despotism on which he had determined to enter. He turned the noble

teachings of Epaminondas to his own advantage after a fashion illustrated in many other remarkable historical instances. He invaded Thrace, and was successful for the time. He then attacked Byzantium, but here Athens came to the rescue and prevented its conquest.

Demosthenes. The Athenians appear at that time to have been the only Greeks who regarded as a national interest the defence of all the Greek states against invasion. Their great orator, Demosthenes, saw from the first the selfish and ambitious purposes of Philip, and devoted all the power of his marvellous eloquence and argument to arouse his people to a sense of the danger which threatened them. His great orations, known as the "Philippics," were directed against the projects of the Macedonian sovereign. Philip, however, made some conquests which helped to remove certain of the practical difficulties in his way, and the Athenians had to sign a treaty of peace that even Demosthenes felt compelled to recommend, and helped to negotiate with Philip. The Athenians believed themselves safe under this treaty, and Philip succeeded in persuading them to give him a vote in the Amphictyonic Council. This celebrated council is described by tradition as having been the creation of Amphictyon, a lawmaker of somewhat mythical origin, and was intended to have the general direction of all the affairs of Greece. It was made up of twelve members, selected from among the best and most high-minded representatives of the various Greek cities and states, and was in fact a sort of Hague Tribunal devised at the opening of history.

A Wonderful Orator. Philip was able to impress the Greek states for a while with the belief that his policy was purely patriotic, and turned his aggressive projects towards regions outside the boundaries of Greece. Demosthenes, who now began to understand the designs of Philip, rose to a splendid height of eloquence and statesmanship in his efforts to prevail upon the Athenians not to risk their national independence. Demosthenes was unquestionably the greatest orator of the ancient world. His style is not florid, is never redundant, but its power of condensed expression is marvellous, and the reader feels that no other word was needed in any sentence to convey the full meaning of the orator. Argument directs the very passion of each oratorical outburst, and passion itself seems able to lend new force to each argument. Philip's attack on the Olynthian state occasioned some of the most powerful speeches delivered by Demosthenes, and they inspired Athens to take the field in defence.

Athens did not make any success from the beginning of her operations, and it may be that the heart of the Athenian state was not entirely with the policy of war. The Athenians were easily induced to come to terms of peace with Philip, terms which Philip made especially convenient for himself. Then ensued an interval of peace for about four years, so far as Athens was concerned, and during that time Demosthenes devoted himself with all his energy and perseverance to the task of creating an anti-Macedonian party in Athens. A defensive league was formed in which Thebes and other Greek states supported the cause of Athens. Philip was equally resolute in the pursuit of his own designs, and with the battle of Chæronea in Bœotia the independence of Greece came to an end during that part of the world's history.

A Great Soldier's Initiation. The victory at Chæronea was brought to its completion by a splendid cavalry charge, and that charge was led and directed by Philip's son Alexander, of whom the world was soon to hear much more. Philip behaved not ungenerously towards his conquered opponents. The Thebans were compelled to receive a Macedonian garrison, and to acknowledge themselves subjects of the Macedonian king, but they were not otherwise treated with severity. From the Athenians Philip exacted the recognition of his conquering rule, but he returned the prisoners he had taken, and he inflicted no cruelties on his defeated enemies. We must not extol the clemency of Philip too highly because of the course which he took after his great victory. His mind was filled with a project to make the Greeks his confederates in a scheme of conquest of a yet more venturous nature, which he could not hope to carry out without the assistance of the Grecian states. He convened a congress at Corinth, to be composed of delegates from the great cities of Greece, and when the congress assembled caused it to be made known that Greece was to have a constitution of her own, under which complete local freedom was to be given to each state, on condition that these states submitted to the sovereignty of Macedonia. Each state was to enter into a solemn treaty of alliance with Macedonia, some cities were to receive Macedonian garrisons, and Philip was to be commander-in-chief of the whole army.

The Close of a Great Reign. Then Philip announced his purpose to undertake the conquest of Asia, and his desire to make his great effort as the representative of the whole Greek federation, as well as of his own kingdom. The enterprise aroused much sympathy and even enthusiasm among the Greeks. But the career of Philip was brought to a sudden close before he had made any great advance towards the realisation of his most ambitious plan. He had many private enemies in and around his own household, and he was suddenly attacked and assassinated while taking part in his daughter's marriage procession. He was forty-seven when his life of conquest was thus brought to a close. His reign had lasted nearly twenty-five years, and during that time he had accomplished wonders for Macedonia. When he succeeded to the throne it was an unimportant stretch of territory, and he had made himself and his people the masters of all Greece. His fame in history does not, however, depend so much upon his own achievements as on the more marvellous exploits of his son, who will be known to all time as Alexander the Great.

Continued

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THE BOOKS OF THE FIRM

Purposes of Books used in Business. Show-room Records. Double-entry Bookkeeping. The Sales Book

By A. J. WINDUS

The Books of the Firm. We approach at length the books used by Bevan & Kirk in their business, and it may be noted in this connection that the constant and minute registration of everything that takes place and the tremendous value put upon time are two of the distinguishing features of business life.

It will be convenient if we classify the books of Bevan & Kirk under two headings (as pertaining either to the show-room or to the counting-house), explaining their several purposes preparatory to resuming our study of the firm's system of bookkeeping.

Show-room Records

1. Price Book. Register of goods stocked or "carried," giving manufacturers' names and numbers, short description of the goods, their buying and selling prices, and the "Call" numbers.
2. Letter Book. Book with blank numbered leaves of specially thin paper, in which outgoing letters are copied by means of the copying-press.
3. Order Guard Book. Book with blank leaves of specially stout paper, into which are pasted, as they arrive, the orders received.
4. Telegram Book. Book of stamped telegraph forms, with blanks interleaved. When writing out a telegram, a carbon sheet is inserted between the stamped form and the blank underneath—a facsimile of the message being thereby obtained. The original telegram is torn out and despatched, whilst the duplicate remains for future reference.
5. Agency Order Books. These are constructed on the same principle as the Telegram Book, a separate book being kept for each manufacturer. Thus there is one for Jones & Co., one for Wm. Smith, and one for the Berlin Manufacturing Company. Suppose an order comes in from Manchester for goods of the Berlin Company's make. A copy of the order, with carbon duplicate, is written out in the appropriate Agency Order Book and transmitted to Berlin, and the original order is then pasted in the Guard Book, as explained.
6. Agency Commission Book. Register of dates, names, and amounts of invoices sent out by Berlin Manufacturing Company and others for whom Bevan & Kirk act as agents for goods supplied in execution of orders from Bevan & Kirk's customers—whether such orders come direct or through the agents.

   A certain number of pages in the book is allotted to each agency, and care must be exercised to ensure the invoices being entered under the proper headings—that is to say, under the names of the manufacturers from whom they come. In order that the Agency Commission Book shall contain *full* lists of invoices, it is customary when goods are sent direct from manufacturer to customer to advise the London representatives, Messrs. Bevan & Kirk, by sending them either a tissue copy of the invoice which has been despatched to the customer or the invoice itself. In the latter case, a copy is made and kept by Bevan & Kirk for their own use; this done, the original goes away again on its journey to the actual purchaser of the goods.
7. Address Book. Register of the names, addresses, telephone numbers, etc., of the firm's customers.
8. Stock Order Book. Similar in construction to No. 5, but only one book is kept. It contains a record of orders for stock given by the firm to manufacturers and others.
9. Box Files. By the use of these files, one for each agency, the correspondence with manufacturers is rendered easily accessible. Quotations, memoranda, and letters received are filed in datal order, copies of replies being attached thereto. If, moreover, instead of using the Stock Order Book, an order is given in a typewritten letter, carbon copy of same is placed on file.
10. Delivery Book. A book of printed forms with counterfoils, used in connection with the despatch of goods. The customer who takes delivery of the goods, or the carrier who receives them in trust to be forwarded to their destination, has to sign one of these forms as an acknowledgment of receipt of the goods therein referred to.

This summary list is complete so far as the show-room of Bevan & Kirk is concerned. That being the case, let us anticipate the question which may arise in the minds of students: "Why is it the show-room does not keep some sort of book in which to enter all goods coming in and going out (in other words, a *stock book*), so that it could always be ascertained what goods were on hand?"

In order to clear up this point, we must take the risk of trespassing a little on our next bookkeeping lesson. If we were to put the question to the firm, their answer would probably be somewhat as follows: "We can tell from the invoice book the quantity we have lately bought, and from the day book the quantity we have lately sold of any of the 'lines' in which we deal; and it is the duty of the stockkeeper to inform us when sizes or numbers in a particular stock are running low. We 'take stock' ourselves once a year, or oftener, when our accounts are made up, and

we should consider it a waste of time to keep a stock book such as you suggest.

Because Bevan & Kirk do not keep a stock book, we cannot be sure that Brown & Jones get along without one. On the contrary, business methods differ, not merely with different classes of business, but it may almost be said that no two businesses of similar character are run on quite the same lines.

Double-entry. At the same time, there could scarcely be a more perfect illustration of "unity in diversity" than is afforded by trade viewed as a whole. The one and only object of business is to make money, but this single object is pursued by innumerable methods and fostered by countless aids. Among the latter must be reckoned double-entry bookkeeping; and here, again, we have "unity in diversity," for there is unanimity in regard to the fundamental principles of double-entry existing side by side with the utmost diversity in applying those principles. That is why some authorities assert, wrongly as we believe, that bookkeeping is not an exact science. Certain it is that knowing how to keep the books of a brassfounder, for example, will not help us very much with theatre accounts until we grasp the truth that, although the principles of double-entry are essential and unchanging, we may apply them in any way we please to suit the special requirements of a business.

The "Day Book." We need not linger over this point, as we may have occasion to revert to it; but a simple illustration may be helpful. In double-entry it is necessary to keep a record of sales. Some business men call such record a *sales journal*, others a *day book*, but that does not alter the character of the transactions recorded therein—they are still sales, so that this is merely "a distinction without a difference." If we refer to what was said about the entering desk, we shall find that some houses copy their invoices in a press copy book, and that from thence the dates, names of customers, and amounts of the several sales are entered in a book which in form is a condensed day book, but in name is a sales journal. Other business houses, as explained, make full entries in the day book itself. But there is no real difference.

It will be remembered that in a previous chapter we considered the petty cash book kept by Bevan & Kirk's junior clerk. In our study of this book we had arrived at the point where—the expenditure for the month of September, 1905, having been analysed under various columnar headings—we desired to learn how the information thus given could be utilised. But there were "lions in the path." We were unable to go a step farther in this direction until we had grappled with the chief principles of double-entry. These have now been dealt with. It is too much to hope that they have been wholly mastered by the earnest student, but, at least, he need no longer fear them, and a careful scrutiny of the table of books used in the counting-house [see next page] will clear the way for a general advance.

Let us take courage from the thought that, being now in possession of the broad outlines of Bevan & Kirk's system of bookkeeping, all that remains is to fill in the outlines properly. This is chiefly a matter of learning how to interpret in terms of double-entry all or any of the firm's operations. To do this successfully we must not overlook the important distinction between books of original and books of final entry. What is meant by "original" and "final"? The answer to this will be found in the answer to another question. "What are the books of final entry?" Our list shows that they are *ledgers* of one sort or another. Ledgers are in a class by themselves, storing up information contained in other books.

The Use of the Ledger. Thus a ledger may be described as a storehouse of information which is gleaned from other books and classified under appropriate headings called Accounts. It follows that there should be no items in the ledger except such as have been "posted" thereto from the books in which they were originally entered. Transactions should be recorded in the ledger through the medium of the books of original entry only. There are eight of the latter in our list, and, with the exception of the journal proper, each book or sectional journal is devoted to a single class of transaction. The cash book is for monetary receipts and payments (with special columns for discount), the invoice book for credit purchases, the day book for credit sales, etc.

A Selection of Transactions. But practice is better than precept. With a view to testing our ability to express business operations in the language of double-entry bookkeeping, we will take the following selection from those which occurred during the period from 20th to 30th September last. The information contained therein has been collected from various books of original entry, and we are asked to indicate the books to which the items respectively belong.

September, 1905.

(*a*) 20th. Cheque, £5, drawn for petty cash.
(*b*) Stamps purchased, 5s.
(*c*) 21st. Invoice passed for goods received from Ord & Mackay, £57 10s. 0d.
(*d*) Mr. Allday purchased for cash goods value £1 5s. 9d.

Goods sold on credit as follows:
(*e*) Harold Springer, £2 12s. 0d.
(*f*) J. Bruce, £11 4s. 8d.
(*g*) Aird Bros., £44 9s. 10d.
(*h*) 22nd. Received from Brown & Co., Ltd., cheque, value £10 1s. 9d., in settlement of their a/c for £10 6s. 11d., less 2½ per cent. discount, 5s. 2d.
(*i*) Drew on J. Wake for £20 10s. 6d., at 3 months' date, in settlement of account to 19th September.
(*j*) 23rd. Paid from petty cash salaries and wages, as per salary book, £11 9s. 0d.
(*k*) Paid Rice and Sons cheque value £49 4s. 3d., in full of their account £50 9s. 6d., deducting 2½ per cent. discount, £1 5s. 3d.

A TYPICAL TABLE OF BOOKS USED IN THE COUNTING-HOUSE

No.	Posting Contraction.	Name.	Explanation.
			BOOKS OF *ORIGINAL* ENTRY
1	C.B.	Cash Book	Record of all moneys received and lodged in the bank and of all cheques drawn.
2	P.C.	Petty Cash Book ..	See definition *ante.*
3	P.B.	Postage Book	Ditto.
4	Jl.	Journal	The functions of this book and the modern system of subdividing it into invoice book, day book, etc., will be dealt with in a special paragraph.
5	I.B.	Invoice Book	Journal of goods bought on credit in which is entered (*a*) number and (*b*) date of each invoice, (*c*) name of creditor, (*d*) amount of the invoice.
6	R.O.	Outwards Returns Book.	Converse of No. 5, being a journal of goods returned, in whole or in part, by Bevan & Kirk to the persons from whom they were bought. Returned empties, shortages and allowances claimed by the firm are also entered herein.
7	D.B.	Day Book	Journal of goods sold on credit (see remarks on "Entering Desk" *ante*).
8	R.I.	Inwards Returns Book	Converse of No. 7, being a journal of goods returned, in whole or in part, to Bevan & Kirk by their customers. Shortages and allowances claimed by the latter are also entered herein.
			BOOKS OF *FINAL* ENTRY
9	B.L.	Bought Ledger.. ..	Book of accounts of those persons from whom Bevan & Kirk buy goods on credit.
10	S.L.	Sales Ledger (or Sold Ledger).	Book of accounts of those persons to whom Bevan & Kirk sell goods on credit.
11	P.L.	Private Ledger ..	Book of private accounts, such as partners' capital and current accounts, loan accounts, etc. Copies of the periodic Balance Sheets and P. and L. accounts also appear herein.
12	G.L.	General Ledger ..	Book containing (*a*) *real* or *property* accounts, such as cash, stock-in-trade, etc.; (*b*) *nominal* or *temporary* accounts, as trade expenses, salaries and wages; (*c*) accounts which do not find a home in any of the other ledgers.
			SUPPLEMENTAL
13		Paying-in Books ..	Two books supplied to Bevan & Kirk by the Commercial Banking Company—the firm's bankers—to facilitate the payment of money into the bank. One is a *town* paying-in book for cash, bank-notes, town cheques, etc.; the other, which has paper of a different colour, is a *country* paying-in book for country cheques, etc. These books will be described more fully hereafter.
14		Cheque Book	Book of forms, each bearing an impressed Revenue stamp value one penny, issued to the firm by their bankers. Whenever Bevan & Kirk desire to draw money from the bank, or to pay an account by cheque, they fill out one of these forms for the required sum and sign it with the firm-name. The amount is paid by the bankers on presentation to them of the form or cheque as it is now termed.
15		Bank Pass Book ..	Book issued by the Commercial Banking Company showing the state of Bevan & Kirk's banking account according to the bank ledger. The book derives its title from the fact that it *passes* between the firm and the bank. Its uses will be explained presently.
16		Ledger Indexes ..	A ledger index ought to reveal the folio of any and every account in the ledger. Therefore, immediately a new account is opened, the full name and ledger folio should be recorded in the index under the appropriate alphabetical heading. Some indexes are bound up with their ledgers, while others are bound up as separate books. It is entirely a matter of convenience which method is adopted. For the firm's Bought and Sold ledgers—collectively styled trading ledgers—there is one B.L. index and one S.L. index. These are bound up apart from their ledgers, and separately from each other. But the P.L. index forms the front part of the Private ledger itself, and so with the General ledger. To avoid continual borrowing of the show-room address book, the accountant is in the habit of adding full postal address after each name in the trading ledger indexes, but the rule is not to allow addresses to appear on the ledger accounts themselves.
17		Bill Book	The Bill Book actually consists of two books, which we may call P. and R. P. extends to about the middle of the whole book; R. does the same, but starts from the other end, the book having been turned right over so that P. and R. are upside down to one another. This seems cumbrous, but is, in reality, very simple. The one part of the book contains a record of bills of exchange payable (P), the other a record of bills of exchange receivable (R.). Bills payable are one thing, and bills receivable are another, but for various reasons it is convenient to have a compact record of them such as the double book affords us. Fuller explanation must be deferred until the subject of bills compels our close attention.
18		Salary Book	Memorandum book showing how the weekly total of £11 9s. (*vide* P.C. Book) is made up.
19		Letter Book	Book (similar to that described in the Show-room Records) in which are copied outgoing letters on counting-house matters only.

(*l*) 25th. Paid postage of parcel to Williams Bros., Cape Town, 5s.

(*m*) Accepted Henry Norgate's draft at 60 days' for £55 4s. 11d., payable at the Commercial Banking Co., in settlement of account to 19th September.

(*n*) 26th. Received and discounted J. Wake's acceptance for £20 10s. 6d., the bank's charge for discount being 3s., or at the rate of 3 per cent. p. a. (see Pass Book).

(*o*) 27th. Paid from petty cash cost of advertisement for town traveller, 3s ; and 1s. 9d. for brown paper..

(*p*) Mr. Bevan drew £5 and Mr. Kirk £3 on private account.

(*q*) 28th. J. Bruce paid cheque £11 4s. 8d. less discount of 3¾ per cent. for cash, 8s. 5d.

(*r*) 29th. One quarter's rent of business premises, £37 10s. 0d., paid by cheque.

(*s*) 30th. Received of Jones & Co., cheque for £29 8s. 2d., in payment of commission, £27 6s. 0d., and expenses, £2 2s. 2d., to 30th June, 1905.

(*t*) Invoice passed for goods received from Ord & Mackay, £46 15s. 3d.

(*u*) Goods returned by Aird Bros. (wrong pattern), £3 7s. 4d.

The best way to answer the question, "Where were the above transactions first recorded ?" is for the student to mark down in pencil opposite each item the name of the book whence he believes it was derived. Take (*e*) for example. Goods were sold on credit to Harold Springer, £2 12s. Opposite this transaction we should write down the words "Day Book," or the contraction D.B., to signify our belief that transaction (*e*) was entered first in the day book. The marking of all the items is recommended.

The majority of these transactions are of a simple character, but one or two may be described as compound, and almost all possess special features, so that we work through the entire list, beginning with :

(*a*) September 20th. Cheque for £5 drawn for petty cash. We must conclude that the cheque was presented for payment and cashed at the bank, because, otherwise, it would not have availed for the purpose for which it was drawn. Therefore, the junior clerk has *received* £5 *paid* to him by the bank. With folio 58 of the petty cash book, exhibited in a previous chapter, open before us, we see at once how the junior clerk treats the money thus received. He enters it in the "received" column, on the debit side of the petty cash book, thereby conforming to rule (*b*) given in Part IV. But for every debit there must be a corresponding credit, and, in the present instance, the credit will be found duly entered in the bank cash book under date of September 20th.

NOTE. On page 409, in the "coinage" column, under Egypt, the line £1 = £E ·0985 should read £1 = £E ·985.

Continued

45 BANK CASH BOOK 45

Dr. SEPTEMBER, 1905

Date.	Receipts.	Folio.	Discount.			Cash.			Bank.		
1905.	Brought Forward ..	44	8	9	5				437	9	10
Sept. 21	To Cash Sale, Allday					1	5	9			
	,, Wm. Perryman					5	4	8	6	10	5
,, 22	,, Brown & Co., Ltd.			5	2	10	1	9	10	1	9
,, 26	,, J. Wake's Acceptance discounted.					20	10	6	20	10	6
,, 28	,, J. Bruce			8	5	10	16	3	10	16	3
,, 30	,, Jones & Co. Commission A/c to 30 6 05. 27 6 0										
	Expenses 2 2 2					29	8	2	29	8	2
			£9	3	0				£514	16	11

CONTRA *Cr.*

Date.	Payments.	Folio.	Discount.						Bank.		
1905.	Brought Forward ..	44	12	4	6				355	14	7
Sept. 20	By Petty Cash								5	0	0
,, 23	,, Do.								15	0	0
	,, Rice & Sons		1	5	3				49	4	3
,, 27	,, Mr. Bevan Drawing A/c ..					5	0	0			
	,, Mr. Kirk Do. ..					3	0	0	8	0	0
,, 28	,, Bank charge for discounting Wake's Acceptance.									3	0
,, 29	,, Rent due Michaelmas.. ..								37	10	0
,, 30	,, Petty Cash								10	0	0
	,, Balance carried forward ..	46							34	5	1
			£13	9	9				£514	16	11

Continued from page 738

DRAINAGE OF COUNTRY HOUSES

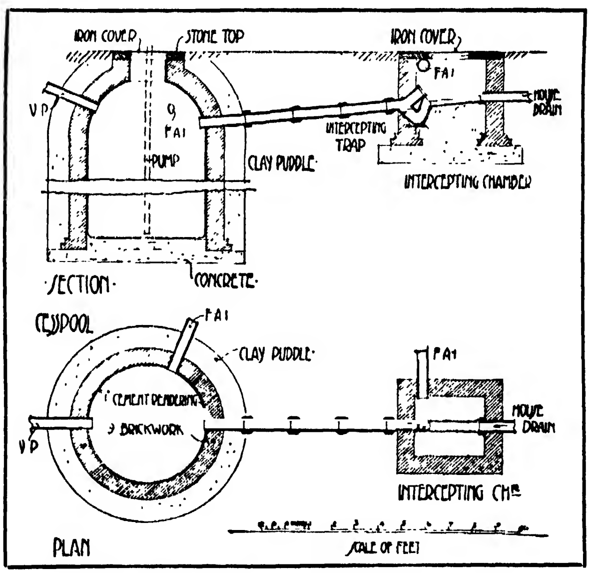
Its Special Requirements and Practice. The Failure of Traps. Drain Ventilation. Drain Testing and Cleansing

By Professor R. ELSEY SMITH

IN the drainage of country houses some features not met with in towns provided with sewerage systems are introduced. The first of these are *sumps*, or *soakaways*, for rain-water. They may be employed when it is not desired to store the rain-water. Such a sump consists of a pit which is sunk in the soil, and which should have a capacity of at least one cubic yard, and should be filled in with hard, dry, clean brick or stone rubbish; it should be at least 6 ft. from the building, and a drain is taken from the foot of the rain-water pipe, so as to deliver the water into the sump. A small chamber may be formed with bricks laid dry around the end of the pipe, to ensure that it is not choked up by the smaller material. Each pipe may have its own sump, or two or three may deliver into one. In dry, porous grounds the size may be kept small, as the water will rapidly disperse by percolation, but in moist and clayey soils the capacity should be large. The actual size will depend upon the amount of water delivered by the pipe; no sump should be formed for this purpose so deep as to reach the level at which water stands naturally in waterlogged ground. Wooden butts are often used to receive the rain-water delivered by a single pipe, but should have an overflow and a drain placed under the draw-off tap which is usually provided.

Cesspools. Cesspools are large receptacles sunk below the ground-level for the reception of sewage. They are of two classes, both generally circular in plan. Those usually required are made watertight, with the bottom of cement concrete, walls and domed top of brickwork set in cement; or the wall and dome may also be in concrete. The interior is rendered in cement and sand [see PLASTERER], and in damp situations the outside may be surrounded with *clay puddle* [see ENGINEERING FOR WATER SUPPLY]. The top has an opening closed with a manhole cover and a perforation for the suction-pipe of a pump, if one is used for pumping liquids only. [45]

The drain which delivers into the cesspool has an intercepting chamber close to it. The cesspool, which should be placed at least 100 ft. from any dwelling, has a F. A. I. and a V. P. carried up a tree or a tall post. Nothing should be led into it but the soil-drains from closets and the scullery sink. The size varies with circumstances; but even a large cesspool, if it has no outlet or overflow (and this is not as a rule permitted), will require pumping out at frequent intervals.



45. CESSPOOL AND INTERCEPTING CHAMBER

The second variety of cesspool is similar in form, but is built dry—*i.e.*, the bricks are laid without mortar. In chalk it may be excavated in the chalk, and remain unlined. Its construction allows the liquids to percolate into the soil, and is only suitable for dry, porous soils in situations where there is no danger of contamination of any source of water supply. Into such a cesspool all wastes, as well as soil-drains, may be taken, and if capacious it will require cleansing only at long intervals. The intercepting chamber and system of ventilation is required, and a small cesspool of this type is sometimes provided for bath and lavatory wastes where the soil-drains are taken to a watertight cesspool.

Storage Tanks for Rain-water. These are employed where separate rain-water drains are used. They are constructed underground in a manner similar to watertight cesspools, but

of much greater capacity. The actual size is regulated by the area from which rain-water is collected and the rainfall of the locality. For every square of 100 ft. of roof drained a provision of 8·3 cubic ft. must be made for each inch of rainfall to be stored, and about half this amount from paved yards. The average rainfall throughout England is about $2\frac{1}{2}$ in. per month but varies considerably in different districts and in different months. Where it forms the only source of supply the capacity for the tanks should be equal to storing four months' supply.

Storage Tanks. The tank [46] may be circular or rectangular, and is sometimes lined with asphalte. [See BRICKLAYER.] It may be provided with a small catchpit and strainer to receive the end of the drain, and to retain any solid matter It must have an overflow, which, if possible, should be taken to a ditch or pond; if taken to the soil-drainage system it must be efficiently disconnected. The tank must have a manhole cover for access, and a lift or force-pump for raising the water to the cisterns supplying the house. The pump must be connected to the well with a suction-pipe, taken down nearly to the bottom of the well, and to the cistern by a delivery pipe. Pipes and cisterns for rain-water should be of iron, not lead, as the rain-water attacks lead.

Subsoil Drainage. Subsoil drainage is required for draining off stagnant subsoil water due to general saturation or to a land spring. The drains are laid with the agricultural drains already described. Pipes of 3 in. diameter are usually employed; a series of parallel trenches are cut, the drains laid in the bottom, and the trenches filled in. The depth of the trench varies with the nature of the soil, from 2 ft. to about 4 ft. 6 in.; the distance apart of the trenches varies usually from 12 or 15 ft. in stiff ground, to from 30 to 40 ft. in loose, porous ground. The trenches when close are kept shallow, and increase in depth as they are spaced further apart.

The ends of the pipes are connected to a 6 in. or 9 in. socketed drain, and taken to a ditch or pond. The outfall should be open to inspection, but closed by a wire grating against vermin. Such drainage may be laid with very little fall, but any general inclination of the ground surface should be followed, where possible, the outlet of the main cross drain being at or near the lowest level of the land to be drained.

Failure of Traps. Conditions arise when the traps previously described may cease to be efficient. The arrangement of a good drainage system should be such as to minimise the effect of their failure. The principal causes of failure in traps are the following:

1. The water-seal may be *forced* by an accumulation of gas on the sewer side if the pressure is sufficient. This most frequently happens with the main intercepting trap from the collection of gases in a sewer. It should not happen with gullies if the ventilation of the drains is well arranged and kept efficient.

2. The water in the trap may be *evaporated* in dry weather to such an extent that the seal ceases to exist. This happens most often to gullies provided to receive surface drainage only from small areas. Such areas are often placed directly under basement windows, and, if a gully placed in one of these becomes inefficient, sewer gas is liable to enter the building through the window. A gully in such a position should have, if possible, a lavatory or sink waste taken into it. This will keep it charged if in frequent use. If this is impossible, the most certain method of protection is to take the drain from the gully, not directly into the main drain, but into another gully which does receive such a waste, and will not, therefore, be liable to dry up even in a prolonged drought. Gullies are not desirable, and, as a rule, are not permitted, in the interior of buildings. If used in any case, the drain from such a gully should on no account be connected with the general drains directly, but must be disconnected as already described.

3. The contents of a gully may be *syphoned out.* This is caused by the creation of a partial vacuum on the inner side of the seal, produced by a full-bore discharge in a neighbouring pipe. The pressure of the air on the upper side of the trap may then suffice to drive before it the water standing in the trap and force the seal, which remains open till the trap itself is recharged. This affects the small traps of sanitary fittings more seriously than gullies, and will be referred to again [see INTERNAL PLUMBER], but the condition may arise in gullies.

4. The contents of the trap may be carried out by the force of *momentum.* When a considerable full-bore discharge takes place the whole body of water may pass through the trap without leaving a sufficient quantity in the trap itself to complete the seal. This is very liable to happen in the discharge of a flushing tank or cistern, and most flushing rims are constructed so as to retain a sufficiency of water to recharge the trap after the main flush is completed.

The Placing of Gullies. It is necessary, therefore, to bear in mind the possibility of the failure of traps, and, in planning drainage, to avoid placing gullies in positions where, in the event of such failure, sewer gas will readily find its way into the building. One useful means of reducing the liability to this danger is to place the gully not directly under the pipe, but at a distance of about 18 in. from it. The pipe is arranged to discharge into an open channel, which may be formed in concrete and lined with cement, or with a half-round channel; but the most complete form is the *slipper gully* [30, page 571]. This is an ordinary gully fitted with a special form of top, including the channel, which is adapted at one end to receive the discharge of one or more pipes, and at the other to deliver the contents into the gully. When fixed, it should have a galvanised-iron grating or wire cover to prevent choking with dead leaves or rubbish.

Ventilation of Drains. An essential feature of a good drainage system is efficient ventilation, which is required to prevent the

accumulation of dangerous gases in the system and to ensure that any gas generated in it or entering it from the sewer may be discharged in such a manner as to be innocuous. Briefly stated, the system consists in providing an inlet for fresh air (F. A. I.) on the house side of the intercepting trap, the construction of which has been already described; and to provide at or near the head or highest part of the drainage system an outlet, which is carried up well above the highest window or other opening into the building, or, better still, to the ridge of the roof. It is not desirable to carry it up a chimney stack, and in no case should it terminate at the level of the top of a chimney flue. When there is no fire in the fireplace below, such flues often act as inlets to the building, and may suck in the gases that we have been at great trouble to exclude from the building. Between the inlet and outlet there must be nothing in the way of a trap or other obstruction to impede the circulation of the air.

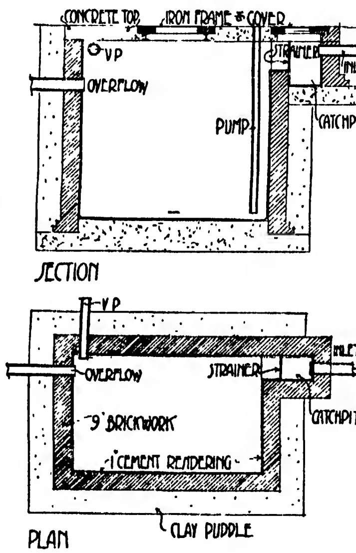
Ventilating Pipe. The ventilating pipe (V. P.) [see PLUMBER] may be a pipe of lead or iron specially erected, but if the soil-pipe from a w.c. occurs within 10 ft. of the head of the drain it may be *utilised*. Every soil-pipe ought to be treated as a ventilating pipe wherever it occurs in the system. The soil-pipe is cut off from the interior of the house by the traps of the w.c. apparatus [see INTERNAL PLUMBER]. The V. P. is connected at its bottom end to the drainage system, and is carried up, without any reduction of its diameter, as straight as possible. All unnecessary bends must be avoided, and the top finished with a fixed dome or globe formed of copper or galvanised iron wire to prevent birds having access and building in it nests, which would destroy its utility.

In some cases an exhaust cowl is added to the V. P. to assist in extracting the air. The pipe should be fixed against a sunny wall if possible, for in such a position the sun will heat the pipe and the column of air within it will be heated, rarefied, and tend to rise, setting up a natural current of air in the pipe, while cool air will be drawn in through the F. A. I. to replace it. But under some conditions this action may be reversed, and it is on this ground that the head of the F. A. I. is provided with a self-closing flap. Lest this should fail, the position selected for the inlet should be such that if for a time it forms an outlet no serious harm may be done. It is best placed as far as possible from any opening into the building.

So long as such a ventilation system operates, it is impossible for any serious pressure of gas to be created in any part of the drainage system, so that the danger of the seal of the gullies being forced is obviated, and if the interceptor is forced the sewer gas has a free road to escape above the roof level.

Testing Drains. The laying of the drain in straight lines and to true falls should be watched during its progress; it may be tested on completion by placing a small mirror in the invert of one manhole and a lamp or candle in the next; even a sheet of white paper will serve in place of the lamp if the manhole cover is open. When truly laid the orifice at the distant end will appear in the mirror truly centred in the near orifice.

Water Test. The test for soundness—that is, the capacity to retain without leakage liquids passing through or standing in the drain—is made by charging the drain with water. It is usual to test each length of drain separately as laid, and later to test the whole system or considerable sections of it, including the manholes.



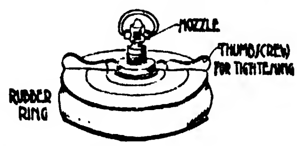
46. RAIN-WATER STORAGE TANK

Drain Plug. For each individual length the lower end of the drain where it enters a manhole is stopped by means of a *plug* or *stopper*. There are two principal classes of these. One consists of two metal plates, the edges arranged to form a V joint, and capable of being adjusted by means of a screw [47]. In the V is placed a thick ring of rubber circular in section. When the plates are separated the diameter is slightly less than that of the pipe to be tested, and it can be placed in the mouth of the pipe. On turning the screw the plates are drawn together, the width of the V joint reduced, and the rubber band, forced into contact with the surface of the drain at all parts, closes the drain completely. Where a considerable pressure of water is to be used, it is useful to strut this plug from the opposite side of the manhole, or it may be blown out bodily by the pressure. Through the centre of the plug an outlet of small diameter is formed, with a tap or screw cap by which it may be closed or opened. This is used for allowing the water to escape after the test is completed. There is also a loop or ring to which a cord or chain may be attached to prevent the plug being washed down the drain if accidentally displaced.

Air-Bag. The other form of plug consists of an *air-bag* [48]. This is placed in the mouth of the drain, and air is pumped into it with an inflator till it swells and closes the orifice. It is held in position solely by friction

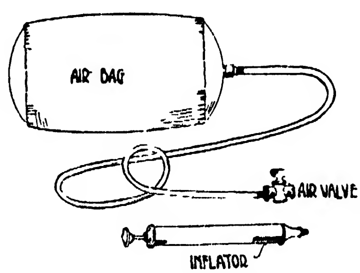
between the bladder and the pipe due to the air pressure within.

The outlet having been closed, the pipe is completely filled with water from its upper end. If the length of pipe is short and the fall slight, a bend may be inserted in the end and turned up so that the level of the water standing in the bend should be about 5 ft. above the level of the outlet. With long runs and fairly rapid falls the head of water in the pipe will be sufficient, and with very rapid falls the head of water may be excessive, but it should not be allowed to exceed 10 ft.



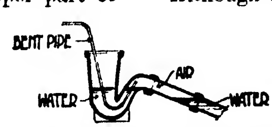
47. DRAIN-PLUG OR STOPPER

Filling the Drain. The filling is best done by a rubber hose, and care should be taken to prevent any water passing into the trench. When the pipe is fully charged the water-level is noted, which may be done by a 2-ft. rule. A convenient plan is to use a strip of white paper, which may be dipped into the water and then stuck against the side of the pipe or gully so that the lower edge just touches the water. If the water remains in contact with the paper without perceptible movement for 20 to 30 minutes the drain is sound. If the water is observed to fall very slightly in the pipe it may be due to absorption by the cement in the joints, and a fresh observation must be made. If the water sinks at all rapidly, or continuously, all the joints in the drain must be examined to find the joint or joints that are defective, and any defective joint must be made good and the test again applied.



48. AIR-BAG AND INFLATOR

Withdrawing the Air. If the upper end of the pipe is formed by a gully or by the pan of a water-closet it is necessary to see that the air is withdrawn from the upper part of the trap, or it will be impossible to fill the pipe. This may readily be done by passing a piece of bent lead pipe—½ in. will suffice—under the seal, so that the inner end penetrates to the upper part of the outlet [49], giving a communication with the air outside and allowing the air in the pipe between the stopper and the water-seal to escape as the water rises.



49. WITHDRAWING AIR FROM GULLY OR W.C. TRAP

When all the pipes converging into one manhole have been found sound, the plug is inserted in the outlet of the manhole, and the manhole and the pipes entering it can be tested together, and, if necessary, by stopping off the various inlets, the manhole can be tested alone, but it is difficult in this case to be sure that all the plugs are perfectly watertight.

This test may be relied upon to disclose any defect in the pipes, jointing, or manholes; such a condition may actually arise in any drainage system should the intercepting trap or the outlet become blocked through any temporary cause, so that it is not an unduly severe one.

Smoke Test. The smoke test is usually applied to new drainage systems to ascertain that the ventilation is in proper order. The test for this purpose may be made with a smoke rocket. This is simply a stout paper cartridge filled with a special preparation which, on being ignited, emits a dense and very pungent smoke. It may be lighted and placed in the intercepting chamber, the lid of which must be at once closed. After a very short interval the smoke should be seen to issue from the top of the ventilating pipe, while none should be seen or smelt at the fresh-air inlet.

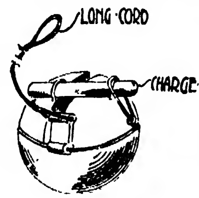
This test is also used for testing the soundness of the joints of the lead and iron pipes within the building [see PLUMBER], for if any of these are in the least defective, the very pungent smell of the smoke will be at once detected. In this case the observer should on no account personally light the rocket, as, if he does so, his nose may not, after smelling it in the manhole, be sufficiently sensitive to detect it in the building. Care must also be taken to see that all doors and windows are closed, and that the smoke, if any escape from the manhole, is not admitted directly to the building at any point. In making this test every room in which there is any fitting connected directly or indirectly with the drainage system should be visited.

This is a useful test to apply to drains and fittings that are not new, and the soundness of which is uncertain. For either purpose the smoke is sometimes generated in a special box, and forced into the drain under pressure by means of an air-pump. This ensures a slight pressure in the system, and adds to the utility of the test, but it is not necessary when the ventilation alone is to be tested.

Although the plumbers' work in fitting up w.c's and other apparatus will be dealt with later, another method of testing the soundness of internal joints may be here dealt with. It is used chiefly in connection with w.c's.

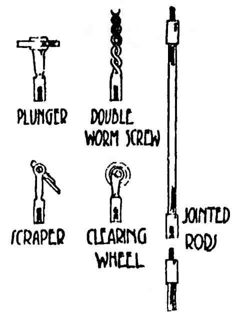
Ferrets. *Ferrets* are made of different varieties by different manufacturers, but the object of all is to introduce into the pipe behind the trap a charge producing a very strong pungent smell which cannot return through the trap, and which, if it is detected inside the building, can only find its way in through some defect in the pipes or workmanship. The form illustrated [50] consists of a ball of wood, with a deep slot cut into it. Across the top of this a thin sealed tube of glass filled with prepared

chemicals is placed through two eyes, and held in position by an elastic band. The cord attached to the ball when the ferret is to be used is placed in the slot below the tube, and the ferret can be inserted under the seal, and will float on the drain side of the trap. A sharp jerk of the cord will snap the tube and scatter the contents in the water, upon which the fumes will be generated; if any defect exists in the pipes or fittings the smell will be detected.



50. FERRET

The Cleansing of Drains. Even self-cleansing drains are liable to some fouling, and should have occasional attention. In case of an actual stoppage of the drain, notice will probably be given by the overflow of one or more gullies. If the stoppage is in the intercepting trap, and the cleansing eye is accessible by means of a chain, as recommended, this should be at once removed. This will allow most of the water held up in the system to escape; the remainder must be bailed out, unless the stoppage can be removed otherwise. If a stoppage occurs at some intermediate point, cleaning rods are used [51]. They are long rods made up of short lengths, which can be screwed together to make any required length. The point of stoppage is located from the manhole above or below it. If the rods can be worked from the manhole above, the *plunger* is fixed to the end of the rod, and the obstruction is pushed down the pipe to the next manhole, and removed. If the upper manhole is inaccessible from being charged with sewage, the *double wormscrew* is fixed to the top of the rod, passed up from below, and screwed into the obstruction, which may then be withdrawn.



51. APPARATUS FOR CLEANSING DRAINS

The *scraper* may be used for clearing partial obstructions in the invert of a drain, and the *wheel* for exploring a drain to locate an obstruction. All traps having containers for gravel or similar material require periodical cleansing, or the trap itself may be blocked. All traps with gratings require to be cleared of leaves or other obstructions regularly, especially in the autumn.

It is desirable to flush out drains from time to time, but it is useless to do this from a small hose, which will never fully charge the pipe. If there is no flushing-tank, a large tub, holding 50 gallons or more, should be filled and emptied rapidly into the top manhole. This will fully charge the outlet and flush out the drain.

Drainage of Complicated Buildings. It has been necessary in dealing with this subject to illustrate the work by plans of a not unusual though not very simple type, but it may happen that in the construction of a large building consisting, it may be, of several blocks more or less detached—for example, a thoroughly modern hospital on an open site—that the drainage of different parts must be dealt with as individual blocks, and that a main drain will take the place assigned to the sewer. But no new principle will be involved. Each block so dealt with, will be treated as if it were an entirely separate and detached building with its own intercepting chamber and trap and system of ventilation. The main drain receiving the sewage from these branches will in turn be provided with an intercepting chamber and trap to cut it off from the public sewer, and will have its separate system of ventilation.

Level of Sewers. The most serious difficulty in dealing with the drainage of any given site occurs when the sewer into which the drainage is to be taken is at such a level that there is difficulty in securing an adequate fall. The level of the invert of any sewer at any given point, or at least at every road manhole, can, as a rule, be ascertained by applying to the surveyor or engineer of the authority controlling the public sewer.

This should be done in all cases where a basement storey or storeys are intended to be introduced, or very great difficulties may result when the drainage comes to be dealt with. If this is done in good time, a little alteration in the floor levels may get over the difficulty. There are districts where the local authorities decline to connect any drain from a basement storey with the public sewer, on account of the occasional liability to flooding when the sewers are fully charged.

Continued

ARCHITECTS, CHEMISTS, & PRACTICAL EXPERTS

Architects as Public Servants. Public Analysts. Inspectors of Weights and Measures. Other Technical Appointments. Women Inspectors

Continued from page 701

By ERNEST A. CARR

CONSIDERING the vast number of town halls, schools, asylums, public baths, and other costly and extensive buildings erected and owned by local authorities, it is a little startling to discover how few chief architectural appointments are comprised in the municipal service. The explanation of this curious anomaly is twofold. In the first place, the leading county and borough surveyors are generally both willing and fully competent (as we saw when discussing those posts) to prepare complete plans, with specifications, for municipal buildings of moderate pretensions, at least; and their services are freely employed in the designing of libraries, baths, power stations, and similar public structures. When, however, a building of special importance is contemplated, or one whose planning involves peculiar difficulties, it is the very general practice of public authorities to organise a competition for a prize design amongst qualified architects. A practitioner of distinction is engaged to act as assessor, and substantial premiums are awarded for the plans of greatest merit. The scheme ultimately chosen is then carried into effect, under the supervision either of the local surveyor or of the architect who evolved it.

In the latter event, payment is usually fixed by scale, the terms being often 5 or 7½ per cent. of the total cost of erection. When we consider the enormous sums of money expended on the greater municipal buildings, it is evident that local councils are among the most lucrative clients of the architect. Such occasional commissions, however, limited as they are to the performance of individual contracts, cannot be said to constitute municipal employment.

Architects as Public Servants. Speaking generally, only the authorities for counties and leading county boroughs have sufficient work of building and reconstruction on their hands to justify them in adding the post of architect to their permanent staff, though many lesser bodies appoint architectural assistants to their surveyor or engineer. The London County Council, whose position with regard to building matters is of unique importance among local authorities, has a considerable staff of well-paid architectural experts, headed by a superintending architect at £2,000 a year. Edinburgh adopts the system of proportionate payment. Its architect's emoluments are a nominal retaining fee of £50 a year, 3 per cent. on all new work entrusted to him, and 5 per cent. on alterations. Among smaller authorities the mode of payment is usually by a fixed salary, which may be anything between £400 and £900. The Manchester Corporation pays its architect £700 a year, and this figure probably represents the average value of such posts.

The difficult question of an architect's training will be found fully considered in the course on ARCHITECTURE, and municipal differs so slightly from private work that nothing can usefully be added here on the matter. Within the service, as without, the diplomas of the Royal Institute of British Architects are of paramount value to candidates.

Assistantships. The great excess in numbers of architectural assistants over architects proper in the municipal service needs no explanation, in view of what has already been said on the practice of appointing assistants where no principal exists. The rate of pay is practically the same as for assistant surveyors. £120 to £150 is the average salary for junior architectural assistants, and £200 to £250 or £275 for senior and chief positions. To a young architect of student rank, or one who has but lately taken his A.R.I.B.A., these figures are perhaps sufficiently attractive; but in weighing the claims of public employment he should not lose sight of the unusual paucity of principal posts in this branch of the service.

London District Surveyors. Despite their official title, these officers perform architectural rather than surveying duties. They are, in fact, experienced architects, appointed by the London County Council after passing a special qualifying examination held by the Royal Institute of British Architects; and, although private practice is prohibited in respect of new appointments, a number of the older members are entitled to practise as architects in addition to their official work. Their duty consists in supervising new buildings and all alterations to existing buildings, and to see that these are carried out in accordance with the London Building Acts. They are remunerated by fees according to a statutory scale. The value of the position is shown by the latest yearly return of district surveyors' fees, which average £925 per officer.

Clerks of Works. Shrewd, practical men, with a sound working knowledge of the building trade in all its branches, are constantly in request among local authorities for the post of clerk of works on the architectural or surveying staff. As a rule, the appointment is temporary, in name at least, extending over a single contract only; but capable men are apt to find it so often renewed as to prove practically continuous, and authorities maintaining a Works department are able to offer posts of this class on the permanent staff. The salary paid varies from £3 to £5 5s. a week. A recent advertise-

ment of an urban district council offered £4 4s. weekly to "thoroughly experienced and practical men (between the ages of 35 and 50) able to put in levels, set out, and measure the work."

The qualifications needed to make a good clerk of works have been more carefully summarised by an expert in the following terms: "A man qualified for this position must have a knowledge of the different kinds of material, such as lime, cement, sand, gravel, stone, bricks, etc. He must also know the different kinds of earth work for foundations. He must be able to check bad workmanship at sight. Also, he should have some knowledge of engineering, such as the use of the level, and be able to set out work so as to check contractors as to lines and levels."

Salaries. The London County Council—an employer of building labour on a very large scale—pays clerks of works on the "unestablished staff" a starting salary of £3 3s. a week. A list of applicants is kept, from which appointments are made as occasion arises. Forms of application can be obtained of the Superintending Architect, County Hall, Spring Gardens, S.W. The official intimation further states that "there are also vacancies for temporary employment as clerks of works during the summer months to superintend the painting of the schools, and application for this class of employment should be made to the Architect, Education Offices, Victoria Embankment, W.C."

The system of keeping a list of applicants for such occasional posts as that of clerk of works, *instead of advertising the vacancies*, is followed by a good many authorities. Qualified candidates would therefore do well to forward to their local councils an application for employment, accompanied by copies of recent testimonials, without awaiting an invitation to do so.

Public Analysts. The Sale of Food and Drugs Acts, which are designed to protect consumers from fraud, impose upon local authorities the duty of procuring and analysing samples of food and medicine, and of prosecuting the sellers of those that prove to be adulterated. Samples taken by an inspector for this purpose are submitted by him to a specially appointed chemical expert for examination.

The public analyst, as the municipal chemist is officially styled, has a responsible and difficult duty to discharge. Against his professional skill is pitted every wile by which clever tricksters seek to mask their impostures and secure inflated profits. He must be able to detect the most cunning methods of admixture or dilution, the minutest traces of preservatives and colouring matter; and his methods must be as exact as they are subtle, for the result of his analysis determines entirely the action taken by the council employing him. His smallest mistake may have very serious consequences. Every day, in courts of law, men are convicted of adulteration charges on the evidence of the laboratory alone. It is clearly requisite, therefore, that he should be fully qualified for his task.

To ensure the appointment of none but properly trained chemists, every public analyst is required to satisfy the Local Government Board of his competency. Candidates must be specially qualified in analytical chemistry, therapeutics and microscopy; but registered medical men, their professional training having ensured a sufficient acquaintance with the last two subjects, need furnish evidence of their knowledge of analytical chemistry only.

Qualifications. The Local Government Board's regulations do not, in so many words, insist on any particular degree or diploma for public analysts. In practice, however, that body recognises only a single qualification as satisfactory, and rarely sanctions the appointment of any candidate who is not a Fellow or Associate of the Institute of Chemistry, and who does not possess the certificate of that Institute, granted after examination in therapeutics, pharmacology, and microscopy.

The diplomas of the Institute of Chemistry, and the training exacted of candidates, will be fully considered in the CHEMISTRY Course. We may note here, however, that the special test in the Analysis of Food, etc., which is essential for public analysts, may be taken either at the final examination for the Associateship (A.I.C.), of which it forms Branch *E*, or as a separate subject after the Associates' diploma has been obtained. In the official syllabus of the Institute of Chemistry (to whose very courteous secretary we are obliged for much useful information on the training of analysts) the test is thus defined:

"Analysis of Food and Drugs and of Water, including the Examination and Analysis of any food or drug within the meaning of the Sale of Food and Drugs Acts; the Assay of Alkaloids; the Recognition of Poisonous Chemicals and Crude Drugs ordinarily found in commerce and having well-marked physical characters; the Use of the Microscope in the detection of adulterations, substitutions, commonly occurring parasites, and impurities in Food, Drugs, and Water.

"Candidates in Section *E* are required to show a general knowledge of the Therapeutic Effects of Chemicals and Drugs, and of the quantities which, taken internally, would be injurious or fatal to man."

Although Associates of the Institute are strictly eligible for these posts, it will be found that, in fact, there is little chance of winning an appointment before completing the three years' "study and practice of applied chemistry," which qualify for the Fellowship. In the list of chemists practising as public analysts the initials "F.I.C." occur with almost unbroken regularity after each name; indeed, nearly 95 per cent. of the appointments as public analysts are held by Fellows of the Institute. Degrees in medicine and science are also very frequent.

Emoluments of Analysts. The earnings of public analysts vary widely, not only with the importance of the area for which they act, but also with their individual status in the profession. In some instances they are paid a fixed stipend; more generally they receive a fee (ranging from 7s. 6d. to £1 1s.,

and occasionaly £2 2s.) for each analysis made, a minimum number of analyses each year being assured. A typical instance of this method is afforded by a London borough which pays 10s. per sample, guaranteeing an annual supply which ensures for the analyst a *minimum* salary of about £420. The chemist in question acts also for another Metropolitan borough and a provincial district, public analysts being neither restricted to the service of a single local authority nor debarred from private practice; his income as a public officer may, therefore, fairly be estimated at £1,000 a year.

Manchester pays its analyst a salary of £150, and in addition fees averaging between £450 and £500 a year. This gentleman also holds several similar appointments elsewhere. Indeed, the same is true of practically every successful public analyst. As a result, the earnings of a few leading members of the calling are very large, probably from £1,500 to £2,000 a year; whilst those of less distinguished practitioners may range between £250 and £1,200. Where so small a stipend as the former figure is paid, the borough council often provides its analyst with a properly equipped laboratory without charge. Holders of more important appointments usually furnish their own laboratories, the fees or salary they receive being inclusive.

For a man of the requisite ability the best means of gaining an entry into this fairly lucrative and distinctly interesting branch of the municipal service is to undergo the training necessary to pass the intermediate examination of the Institute, and subsequently to enter the laboratory of a public analyst of some distinction. This will probably involve the payment of a premium, or, for a time, service, either without salary or at a merely nominal one. But this is the most economical and effective method of gaining the special experience needed in order to qualify for an appointment.

Other Posts for Chemists. Apart from the analysis of food and drugs, the most important municipal work available to chemical experts relates to the testing of water, gas, and sewage. Leading positions of this sort are well remunerated. The chemist to the London County Council, a distinguished expert in questions of water pollution and sewage filtration, receives £1,100 a year; and the leading water examiner employed by the Metropolitan Water Board is almost as highly paid. Chemists are necessarily employed at municipal works for the supply of gas or water or the disposal of sewage. The salaries of these officers vary from £150 or £200 to £700, according to their qualifications and the importance of the post. For all professional positions of this class the most useful diploma is the F.I.C. Candidates proposing to specialise in water and sewage analysis should take Branch *F* at their final examination or subsequently.

Where the supply of gas or water is not municipal the local authority protects the interests of consumers by frequent tests of quality. For this work an analytical chemist is often retained at a substantial fee. The gas examiner to the City Corporation receives £400 a year, and several of the Metropolitan boroughs pay almost as much.

The London County Council employs a non-professional staff of gas examiners, under the control of the chief chemist and his assistants. On passing an examination in practical gas testing, candidates are placed on the list of relieving gas examiners, and are paid 10s. a day when on duty. From this relief staff appointments are made as gas examiners on the permanent staff, rising by £5 annually from £120 to £150 a year. Applications for employment should be made to the Chemist, 40, Craven Street, W.C.

EXAMINATION FOR INSPECTOR OF WEIGHTS & MEASURES

Examining Body, Time and Place of Examination.	Subjects of Examination. NOTE.—Only persons already nominated for inspectorships are eligible for examination.	Fees and Age Limits.
BOARD OF TRADE. STANDARDS DEPARTMENT, 7, OLD PALACE YARD, WESTMINSTER, S.W. Examinations are arranged as required.	1. **Dictation.** 2. **Arithmetic** (SIMPLE). 3. **Mensuration** (PLANE RECTILINEAR FIGURES AND SOLIDS). 4. **Elementary Mechanics.** A knowledge of statics so far as relates to the composition of parallel forces, centre of gravity, and the principle of the lever. 5. **Elementary Physics.** (*a*) Units, standards, and physical constants. (*b*) Definition and application of terms and expressions used in elementary physics. (*c*) Effects of heat in the measurement ofelength, weight, volume, and capacity. (*d*) Determination of specific gravities. 6. **Inspection and Verification of Weights, Measures and Instruments.** The mode of testing weights, measures, and weighing and measuring instruments, and the various tests prescribed in the Board of Trade Regulations. Candidates are required to adjust and stamp weights, etc. They are also examined in the Acts of Parliament relating to an inspector's duties, particularly in respect of prosecutions.	£1 10s. 0d. 21 years and upwards.

Inspectors of Weights and Measures. These officers are appointed by county and borough authorities for the protection of consumers from loss arising through faulty or fraudulent weights and measures. Their chief duties comprise the stamping of such weights, measures, and weighing and measuring instruments as prove on inspection to be correct, the seizure of those that are seriously at fault, and the prosecution of vendors for carelessness and dishonesty. The work requires shrewd, keen, zealous men, willing to extend their hours of duty for the sake of paying surprise visits in suspected quarters, and alert enough to compass the outwitting of that wily and dexterous weight manipulator, the itinerant trader of the streets.

The Weights and Measures Act of 1904 requires that every officer appointed in the future, without exception, must be the holder of a certificate of qualification issued by the Board of Trade. This document is gained by passing a theoretical and practical examination, particulars of which are given in the schedule appearing on the previous page. The standard of knowledge exacted by that test is modest enough, save in Subject 6—the actual duties of an inspector's position—in respect of which the examiners' questions and practical tests are very properly strict and searching. Examples of the papers set in the Board of Trade's Examinations can be obtained from Messrs. Eyre & Spottiswoode, East Harding Street, E.C.

Board of Trade Examination. We are indebted to the courtesy of Mr. Howard Cunliffe, Secretary of the Incorporated Society of Inspectors of Weights and Measures, for the following valuable suggestions as to the character of the Board of Trade examination, and the best practical means of preparing for it and of entering this branch of municipal employment.

"The arithmetic and mensuration questions are rarely difficult, but in order that a candidate may successfully answer the physics and mechanics questions he should have a good knowledge of elementary mathematics (Euclid, Books I. to IV.; Algebra to the Binomial Theorem; and a general knowledge of the Trigonometrical Formulæ); in addition to a thorough knowledge of a good text book on general elementary science.

"The legal part of the work can, of course, be learned by a study of the statutes, and of the Board of Trade Regulations. The difficult part of the examination is that dealing with the candidate's practical knowledge of the verification of weights, measures, and weighing and measuring instruments. The most satisfactory manner in which this information can be obtained is by being personally employed in the administration of the Acts as an assistant to an inspector of weights and measures. This is all the more important, because the examination is not an open one, the Board of Trade only accepting those candidates who are appointed to act as inspectors, or such as are nominated by a local authority as possessing sufficient practical knowledge for the proper performance of the duties of an inspector. While it is not unusual for assistants in Weights and Measures Departments to receive appointment or nomination by their local authority, it is very rare that those outside Weights and Measures circles obtain such an advantage, because when local authorities have no candidates in their own employ, they invariably advertise for inspectors holding the Board of Trade certificate.

"At the present time there are upwards of 500 inspectors of weights and measures in Great Britain. In Ireland the duties are performed by inspectors under the Royal Irish Constabulary."

There is a good deal of diversity in the salaries paid to inspectors of weights and mesures. Provincial appointments usually commence at £100 or £120 and advance by annual increments to £150 or £180, with an additional £100 or so for chief positions. The greater authorities, however, are more liberal. The City Corporation, for instance, pays its chief inspector £325, and his subordinates £200 a year. Under the London County Council, verification inspectors receive £135, with yearly advances to £175; and £200 on promotion to the full grade of inspector, rising by £10 and then by £12 10s. yearly to £300. These posts are filled from the ranks of assistants, whose pay begins at 30s. and rises to 50s. a week. Assistants are appointed from the list of applicants kept by the Council, and must, of course, pass the Board of Trade's test before being advanced to inspectorships.

Inspectors Under Other Acts. There are a few further technical appointments about equal in value with those we have just considered, for which no qualifying examination is necessary. Such are inspectorships under the Shop Hours, Petroleum, and Explosives Acts. Candidates for these posts should possess a fair education and some knowledge of the particular statutes concerned. In many of the counties and county boroughs a separate appointment is not made for each class of duties. They are undertaken by an inspector already holding office, in return for an increased stipend. That officer is most frequently the inspector of weights and measures. In London, as in other counties proper, the work under each group of statutes is performed by a distinct staff of officials, however small. The London County Council rate of pay may be taken as typical of such appointments. It commences at £150 a year for men, and rises by yearly increments of £10 to £250.

For women inspectors under the Shop Hours and other Acts the initial salary is £100, and the maximum £150. Candidates seeking any of the inspectorships mentioned in the present paragraph should lay their claims before the county authority; but it must be remembered that in any one area the total number of such posts is small.

Continued

ELECTRIC MEASUREMENT

Units and Standards. Legal British Units. The One-Ohm Standard. Resistance Boxes. How to Measure Resistances. Wheatstone's Bridge

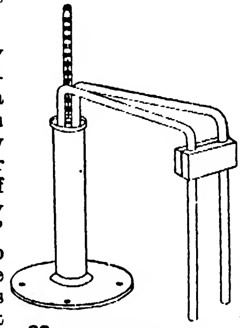
Continued from page 672

By Professor SILVANUS P. THOMPSON

IN a former section [page 291] it was told how the strength of a current is expressed in terms of a certain unit of current called *one ampere*, and measured by an instrument called an *amperemeter*. It was also told how the amount of an electrical effort, or electromotive force, is expressed in terms of another unit called *one volt*, and measured by an instrument called a *voltmeter* [page 292]. Subsequently [page 669] it was further explained how these two things, the electric effort which drives the current and the strength of the current thereby created, are related to a third thing—namely, the resistance of the circuit, resistance being expressed in terms of a unit called *one ohm*. The rule connecting together these three quantities, known as Ohm's law, is of vital importance in understanding the subject of the present chapter. It is to be found on page 670, to which the reader should turn before attempting to learn the principles of electric measurement.

Units and Standards. Every physical quantity needs for its expression the mention of a number and a unit. When you want to tell a man how long a piece of timber is, you may say "fourteen feet," or "thirty-four inches." Or, to describe the weight of anything, you may say "twenty tons," or "three-and-a-half ounces." Now, such expressions are all made up of two parts, the pure numeric and the name of a unit. The numeric tells how many times over the unit must be taken in order to arrive at the quantity in question. Everyone knows that you cannot express lengths in ounces, nor weights in feet. Each quantity must be expressed in terms of *a unit of its own kind*, lengths in terms of a unit of length, weights in terms of a unit of weight; and hence, to express the amount or strength of an electric current, it must be expressed in terms of the unit of current, as so many *amperes*. A unit of any of these physical quantities means a particular amount of that kind which has been agreed upon, or decided by law, to be taken as a basis for measurement. Thus, *one foot* is a unit of length—that is, a particular length, fixed by national consent in terms of which other lengths can be expressed. Again, *one second* is a unit of time, in terms of which other times can be expressed. In some cases a unit can be embodied in a concrete way in a *standard*. The wooden rod, one foot long, called a foot-rule, is a standard which embodies the unit called one foot. The lump of iron or brass called one pound is a standard in concrete form. It will be noted that a *unit* is a kind of legal definition or denomination of a measure, while a *standard* is an actual thing which embodies it. A gallon in this country is legally defined as the volume occupied by 10 pounds of water; the pot made to fit this definition is a standard embodying the unit.

Now, in matters electrical we have three chief units, the *ampere*, the unit of current; the *volt*, the unit of electromotive force; and the *ohm*, the unit of resistance. Now, unfortunately, we cannot have a standard ampere to carry about in our pockets like a foot-rule, but we can have a standard amperemeter, or ampere balance, such as that kept at the Board of Trade. But we can have a standard volt—that is, we can manufacture a standard cell which will have a constant voltage, against which other voltages can be checked. And we have a standard ohm—namely, a piece of wire such that it offers exactly that particular amount of resistance to an electric current that is denominated as *one ohm*.



32. STANDARD ONE-OHM COIL

Legal British Units. In the year 1894 the late Queen Victoria signed an Order in Council in which she approved and made legal certain new denominations of standard, which had been prepared and verified by the Board of Trade under the Weights and Measures Act of 1889. Amongst these were the *ohm*, the *ampere*, and the *volt*. It may be noted that these three words thus became legal British words, and that the word *ampere* is spelled without an accent and without a capital. The three legal British standards are as follows:

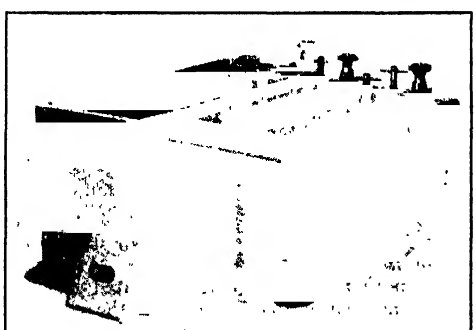
1. *The ohm.* A standard of electrical resistance denominated *one ohm*, being the resistance between the copper terminals of the instrument marked "Board of Trade Ohm Standard, Verified 1894," to the passage of an unvarying electrical current when the coil of insulated wire forming part of the aforesaid instrument, and connected to the aforesaid terminals, is in all parts at a temperature of 15·4° C.
2. *The ampere.* A standard of electrical current denominated *one ampere*, being the current which is passing in and through the coils of wire forming part of the instrument marked "Board of Trade Ampere Standard, Verified 1894," when, on reversing the current in the fixed coils, the change in the forces acting upon the suspended coil in its sighted position is exactly balanced by the forces exerted by gravity in Westminster upon the iridio-

platinum weight marked A, and forming part of the said instrument.

3. *The volt.* A standard of electrical pressure denominated *one volt*, being one-hundredth part of the pressure which, when applied between the terminals forming part of the instrument marked "Board of Trade Volt Standard, Verified 1894," causes that rotation of the suspended portion of the instrument which is exactly measured by the coincidence of the sighting wire with the image of the fiducial mark, etc.

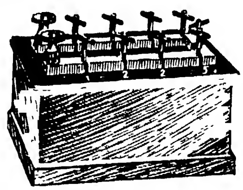
It will be noted that the standard ohm is a *particular coil of wire, while the* other two standards are balances which turn to special marks when the standard amount of current or of voltage has been reached. Fig. **32** depicts a *standard one-ohm coil,* a coil of platinum-silver alloy, wound in a flat double spiral, and enclosed in a thin, flat, watertight box, provided with stout copper electrodes.

Secondary Standards. From the primary standards copies can be made, just as our yard-sticks and foot-rules are made from the standard yard kept at the Board of Trade. Coils having their resistance adjusted to one ohm are sold by instrument makers; and coils that have definite multiples of one-ohm resistance, from $\frac{1}{1000}$ ohm up to 100,000 ohms, can also be purchased. Amperemeters can be calibrated by comparison with the ampere balance of the Board of Trade, or are more often calibrated by comparison between the deflection indicated on their dial and the amount of current passing through them, as computed by passing it for a given time through an electro-depositing cell where silver is being deposited. A current of one ampere will in one hour deposit 4·0248 grammes, or about 60 grains, of silver. As a secondary standard of voltage there is often employed a *standard cell* —that is, some kind of voltaic cell of which the voltage does not change with time. Of standard cells the best are those of Clark and of Weston. Clark's cell requires to be prepared with the utmost care under very precise conditions. It consists of an anode of pure zinc (or of zinc amalgam) in an excitant of a saturated solution of zinc sulphate, and a kathode of pure mercury in contact with mercurous sulphate to serve as depolariser. It has an electromotive force of 1·434 volts. The Weston standard cell has an anode of cadmium in an excitant of cadmium sulphate, while the kathode is mercury with mercurous sulphate as depolariser. Its electromotive force is 1 025 volts.



34. INTERNAL PARTS OF RESISTANCE BOX

Resistance Boxes. For the purpose of the commercial measurement and numerical comparison of the resistances of telegraph lines, circuits, coils, and conductors, copies of the standard resistance and of multiples of that resistance are made up in sets assembled in *resistance boxes.* A simple form of resistance box is shown in **33.** The top of the box is a slab of ebonite, upon which are mounted a number of brass pieces, separated from one another by narrow gaps, but between which brass pegs or conical plugs can be inserted, so as to connect them electrically together.



33. RESISTANCE BOX

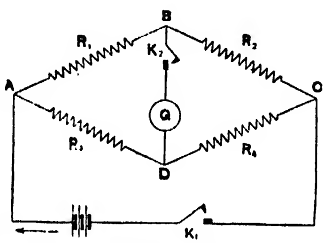
The resistance coils are inside. From each of the brass pieces there passes down into the box a stout brass rod, and between these rods the resistance coils are connected. Each brass plug when inserted in its place forms a bridge or short circuit to the coil below it; so that if all the plugs are in their places any current that may come to the apparatus by wires attached to the two terminal screws will simply pass from one brass piece, through the plug, to the next, and so will flow along the row of brass pieces without meeting with any appreciable resistance. But if any plug is withdrawn, then the current will have to descend into the box and traverse the coil that has thus been unplugged, and ascend again to the next brass piece.

All the coils inside the box need not be made of uniform resistance; and, in order that the experimenter may be able to introduce into the circuit any desired amount of resistance, it is expedient that the various resistances of the coils in the box should be arranged according to some methodical plan. In the cut [33], the coil below the first plug in the front row is 1 ohm, the second 2 ohms, the third 2 ohms, the fourth 5 ohms. If we were to unplug at the same time all four plugs the resistance thus introduced into the circuit would be $1 + 2 + 2 + 5 = 10$ ohms. To introduce eight ohms we must unplug only three of the plugs—namely, $1 + 2 + 5$. The remaining coils are 10, 20, 20, 50, and 100 ohms. So with this series we can introduce any number of ohms between 1 and 200. Thus, to introduce 86 ohms we should have to pull out the plugs corresponding to 50, 20, 10, 5 and 1 ohms, respectively. Some boxes contain more coils reading down to $\frac{1}{10}$ ohm and up to 100,000 ohms. The resistance of each coil is marked on the box.

The coils must be very carefully insulated, and each coil is wound back on itself, so that it exerts no magnetising effect. Fig. 34 gives a

view of the actual construction of a modern resistance box, dismounted to show the coils.

Finding an Unknown Resistance. If we want to find how many ohms of resistance there are in the wire of any particular piece of apparatus, we can do this with fair precision in the following simple way. Connect this unknown resistance into circuit with a suitable galvanometer and with a battery of a sufficient number of cells to produce a current that can be measured on the galvanometer. Then remove from the circuit this unknown resistance, and in its place substitute the resistance box. From the box then remove, by trial, some of the plugs until the galvanometer shows the same current as before, when it will at once be evident that the amount of resistance so unplugged (which can be seen by inspecting the numbers marked at the places where plugs have been taken out) is equal to the unknown resistance.



35. WHEATSTONE BRIDGE

Wheatstone's Bridge. It often occurs that the experimenter desires to know the resistance of some circuit or piece of apparatus, and it may be that this resistance is either larger or smaller than that of the coils in his resistance box; or he may wish to find the value of the unknown resistance with greater accuracy than is afforded by the method of substitution just described. To avoid the expense of a very large and cumbersome box of resistances, recourse is had to a very convenient instrument known as *Wheatstone's Bridge*. This is a device in which the value (in ohms) of an unknown resistance is ascertained by proportion. A diagram of this arrangement is shown in Fig. 35. In this instrument is adopted a grouping of several paths for the current; the grouping consisting essentially of four distinct resistances, which we will call R_1, R_2, R_3, and R_4, connected up in the manner shown. Thus, the current from the battery, entering the instrument at A, finds two routes, one through R_1 and R_2 to C, and the other through R_3 and R_4 to C, and so back to the battery. Now it can be shown that the following very simple proportion holds good between these four resistances. If the numbers of ohms in R_1, R_2, R_3, and R_4 respectively, are such that R_3 is to R_4 as R_1 is to R_2 (by simple rule-of-three calculation), then *no current* will flow from the point B to the point D on connecting these points by a galvanometer. On the other hand, if the resistances are not in proportion, we shall at once know it, for then when we connect the galvanometer across from B to D it will indicate some current. So, then, if R_3 be the unknown resistance, we can ascertain it in the following way. We must know the respective resistances of R_1 and R_2. Then we must adjust R_4 (by unplugging coils) until we get such an amount in R_4 that when we connect the galvanometer across as a bridge from B to D no current runs across the bridge. This process of adjusting till no current flows is called *getting balance*. Then we shall know that the proportion holds good, and since

$$\frac{R_1}{R_2} = \frac{R_3}{R_4},$$

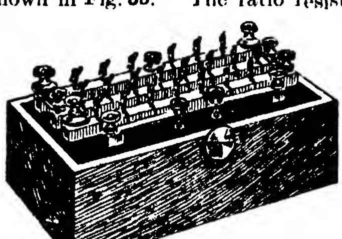
it follows that

$$R_3 \text{ (unknown resistance)} = \frac{R_1}{R_2} \times R_4.$$

Thus, if we had used 1 ohm for R_1 and 10 ohms for R_2, and had then found that to get balance we had to adjust R_4 to be 254 ohms, we should know that the unknown resistance was

$$R_3 = \tfrac{1}{10} \times 254 = 25{\cdot}4 \text{ ohms.}$$

Construction of Wheatstone's Bridge. The two coils R_1 and R_2 in the Wheatstone bridge arrangement are called the *ratio resistances*, or the *proportion coils*. They are kept constant during any one test, and are usually arranged so that their ratio has some convenient value, such as $\frac{1}{10}$, or 100, or 1,000, so as to save trouble in calculating. They are generally made up each of a short row of resistances of 1, 10, 100, and 1,000 ohms, set up at the back of the box, with the necessary plugs. By taking out the 10-ohm plug from R_1, and the 100-ohm plug from R_2, we can get the ratio of 10 : 100, which is the same as the ratio of 1 : 10. These four resistances (R_1, R_2, R_3, and R_4) are sometimes called the *arms* of the bridge. The ratio resistances are two of the arms, the unknown resistance to be measured is a third arm, while the fourth arm (R_4) consists simply of an ordinary set of resistance coils ready to be unplugged.



36. WHEATSTONE BRIDGE, POST OFFICE PATTERN

In practice the battery and the galvanometer are joined up all the time—one from A to C, the other from B to D; but these parts of the circuit are provided, as shown diagrammatically in 35, with keys (K_1 and K_2) to bring them into operation as required. The rule is that after any adjustment has been made by removing or inserting a plug, the battery key (K_1) is pressed down, and then the galvanometer key (K_2) is pressed down, while the galvanometer is observed to see whether balance has been attained.

Fig. 36 depicts a Wheatstone bridge of the Post Office pattern. The ratio resistances are the two sets of three coils each at the back of the box. The front two rows of coils are the adjustable resistance. The two keys are in front of all.

Continued

OBJECT DRAWING & PRACTICAL GEOMETRY

The Circle and Tangents. Representations of the Hexagonal and Octagonal Prisms, Showing Principles Involved

By WILLIAM R. COPE

PRACTICAL GEOMETRY

The definitions of a circle, diameter, radius, tangent, etc., have already been given in the Dictionary of Terms Used in Elementary Geometry (285), but the following facts should also be known :

i. The circumference of a circle is nearly $3\frac{1}{7}$, or, more accurately 3·14159 times its diameter. Archimedes discovered that the ratio lies between $\frac{22}{7}$ and $\frac{223}{71}$.

ii. A straight line which bisects a chord of a circle at right angles passes through the centre of the circle. [Euc. III. 1, Corollary.]

iii. The straight line which is drawn at right angles to the diameter of a circle, from its extremity, is a tangent. [Euc. III. 16, Corollary.]

iv. The angle in a semi-circle is a right angle. [Euc. III. 31.]

200. To Describe a Circle Passing Through Three Given Points, *A*, *B*, and *C*.. Join *AB* and *BC*. Bisect each by the perpendiculars intersecting at *D*. With *D* as centre, and *DA* or *DB* or *DC* as radius, describe the circle required.

This problem shows how the centre of a circle may be found by assuming any three points in its circumference, how to describe a circle about a given triangle, and how to describe an arc equal to a given arc with the same radius.

201. To Draw a Tangent to a Circle Through a Given Point, *A*, in its Circumference. Find the centre *B* and draw the radius *BA*, and produce it to *C*. Make *AC* equal to *AD* (any convenient distance). With centres *C* and *D*, and any radius, describe arcs intersecting at *E*. Draw *AE*, the required tangent.

202. To Draw a Tangent to a Circle Through a Given Point, *A*, Without it. Find the centre *B* of the circle, draw *BA*, and bisect it in *C*. With *C* as centre, and *CA* as radius, describe a semi-circle, cutting the circle in *D*. Draw *AD* the required tangent (Euc. III. 31). By describing a semi-circle on the other side of *AB*, another tangent may be drawn.

203. To Draw a Tangent to an Arc from a Given Point, *A*, in it, when the Centre of the Circle is Inaccessible. With *A* as centre and any convenient radius, describe a circle cutting the arc in *B* and *C*. With *B* and *C* as centres and any convenient radius, describe arcs intersecting in *D* and *E*. Draw *DE*. At *A* draw the tangent *AF* perpendicular to *DE*.

204. To Draw Two Tangents to a Circle to Meet at a Given Angle (say 66°). From the centre *A* draw any straight line *AB*. At any convenient point, *C* in *AB*, make an angle on each side of *AB* equal to *half* the given angle 66°. From *A* draw *AD* and *AE* perpendicular to *CD* and *CE* respectively, and cutting the circle in *F* and *G*. Through *F* and *G* draw *FH* parallel to *CD*, and *GH* parallel to *CE*.

205. To Draw a Tangent Common to Two Equal Circles. First, for *exterior* tangent. Join the centres *A* and *B*. At *A* and *B* erect perpendiculars *AC* and *BD* to the line *AB*. Draw the tangent through *C* and *D*.

Second, for *interior* tangent. Bisect *AB* in *E*. Upon *AE* describe a semi-circle, cutting one circle in *F*. Join *AF*, and through *B* draw *BG* parallel to *AF*. Draw the tangent through *FG*. Another interior and exterior tangent may be drawn, as indicated by dotted lines in **205**.

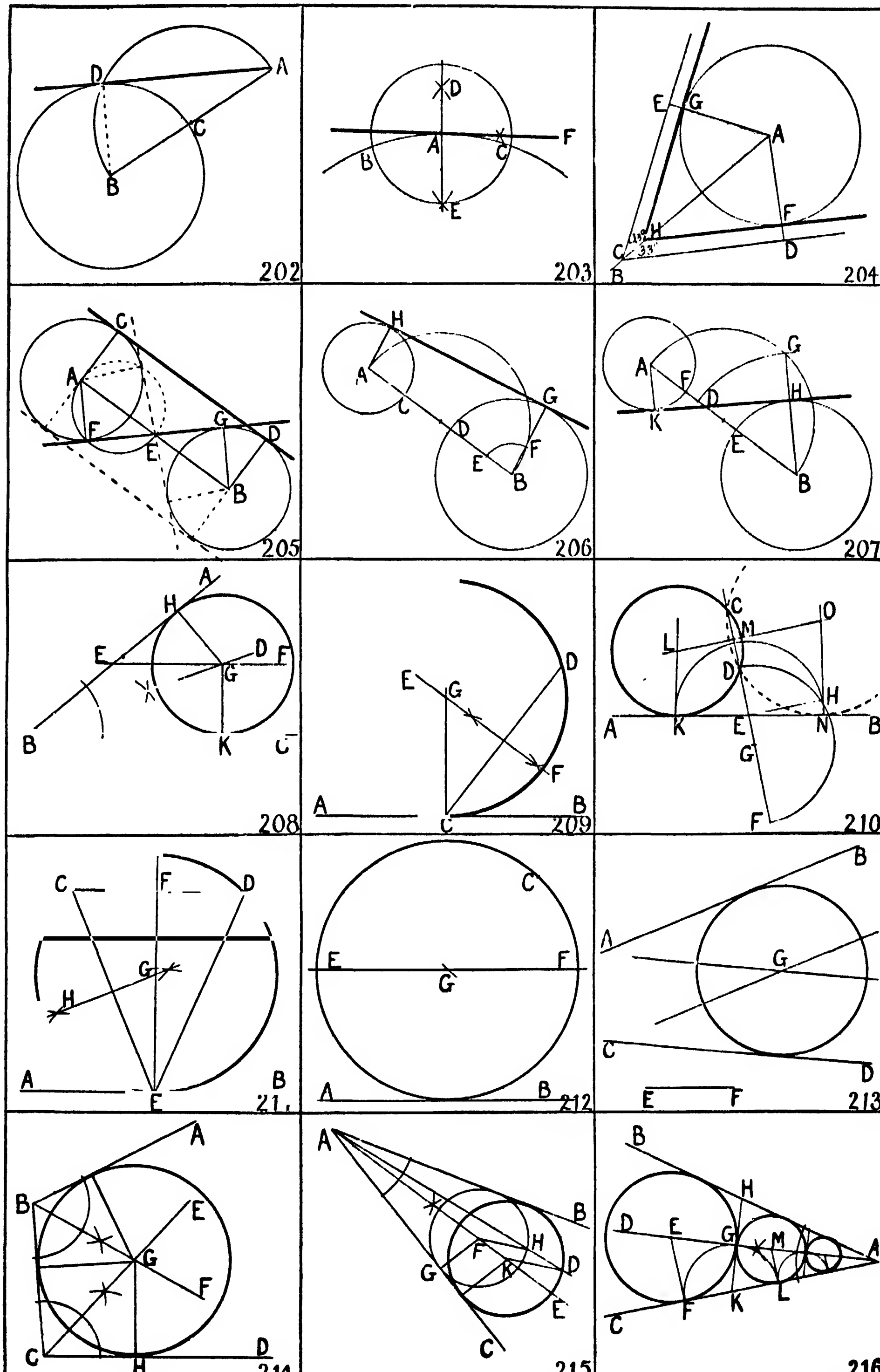
206. To Draw an Exterior Tangent to Two Unequal Circles. Join the centres *A* and *B*, and upon *AB* describe a semi-circle. Mark off *DE* equal to *AC*. With *B* as centre, and radius *BE* (the *difference* of the radii of the given circles), describe an arc cutting the semi-circle in *F* Through *F* draw *BG*, and through *A* draw *AH* parallel to *BG*. Draw the tangent *HG* through *H* and *G*.

207. To Draw an Interior Tangent to Two Unequal Circles. Join the centres *A* and *B*, and describe a semi-circle upon *AB*. Mark off *ED* equal to the radius *AF* of the small circle. With centre *B* and radius *BD* (the *sum* of the radii of the two given circles), describe an arc to cut the semi-circle in *G*. Draw *BG*, cutting the large circle's circumference in *H*, and through *A* draw *AK* (on the other side of *AB*) parallel to *BG*. Through *HK* draw the tangent required. Another could be drawn in this and problem **206** if the semi-circle is described on the other side of the line joining the centres, and proceeding as above.

208. To Inscribe in a Given Angle, *ABC*, a Circle of Given Radius (say ·4 in.). Bisect the angle *ABC* by the line *BD*, and draw *EF* parallel to *BC* and ·4 in. from it, intersecting *BD* in *G*. With *G* as centre and radius ·4 in., describe the circle touching the sides of the angle in *H* and *K*. The points of contact are found by drawing from *G*, *GK*, and *GH* perpendicular to *BC* and *BA* respectively.

209. To Describe a Circle Passing Through a Fixed Point *D*, and Touching a Given Straight Line *AB* in a Fixed Point *C*. Join *CD* and bisect it by the perpendicular *EF*. Through *C* draw *CG* perpendicular to *AB*, and cutting *EF* in *G*. With *G* as centre, and radius *GC*, describe the required circle.

210. To Describe a Circle Tangent to a Given Straight Line *AB* and Passing Through Two Fixed Points *C* and *D* without the Line. Join *CD*, and produce the line to cut *AB* in *E*, and make *EF* equal to *EC*. Bisect



PRACTICAL GEOMETRY: CIRCLES AND TANGENTS

DF in G and draw a semi-circle on DF with radius GF. At E erect a perpendicular to DF cutting the semicircle in H. Mark off EK from E on EA equal to EH. At K erect a perpendicular KL, and bisect CD in M by the perpendicular LM, which also cuts KL in L. With L as centre and radius LK draw the required circle. When the given line AB is not parallel to the line passing through the given points C and D, as in this case, *two circles* can be drawn, the centre of the second one being at O, the intersection of LM produced meeting the perpendicular from N through H.

211. TO DESCRIBE A CIRCLE TANGENT TO A GIVEN STRAIGHT LINE AB, AND PASSING THROUGH TWO FIXED POINTS C AND D, WHICH ARE EQUIDISTANT FROM THE GIVEN LINE. Join CD and bisect the line in F by the perpendicular FE cutting AB in E. Join CE or DE, and bisect it by the perpendicular GH cutting EF in G. With G as centre and radius GC describe the required circle.

212. TO DRAW A CIRCLE PASSING THROUGH A GIVEN POINT C, TOUCHING A GIVEN STRAIGHT LINE AB, AND HAVING A GIVEN RADIUS (SAY ¾ IN.). Draw a line EF parallel to AB and ¾ inch from it. With centre C and radius of ¾ inch intersect EF in G. With centre G and radius GC describe the circle.

213. TO DESCRIBE A CIRCLE OF A GIVEN RADIUS EF, TO TOUCH TWO CONVERGING LINES AB AND CD. At a distance equal to EF draw lines parallel to AB and CD intersecting at G. With G as centre and EF as radius describe the circle.

214. TO DESCRIBE A CIRCLE TOUCHING THREE GIVEN STRAIGHT LINES, AB, BC, AND CD, WHICH MAKE ANGLES WITH EACH OTHER. Bisect the angle DCB by the line CE, and the angle CBA by the line BF intersecting CE in G. From G draw perpendiculars to the three given lines, then either perpendicular (say GH), is the radius of the required circle, to be described with G as centre.

By this means a circle may be inscribed in a triangle.

215. TO DESCRIBE A CIRCLE WHICH SHALL TOUCH TWO GIVEN CONVERGING LINES AB AND AC, AND PASS THROUGH A FIXED POINT D BETWEEN THEM. Bisect the angle BAC by the line AE. Join D with A. From any point F in AE draw FG perpendicular to AC, and describe a circle touching AB and AC, and cutting AD in H. Join FH, and through D draw DK parallel to HF, cutting AE in K, which is the centre of the required circle, whose radius is KD.

216. TO DESCRIBE TWO OR MORE CIRCLES TOUCHING EACH OTHER AND TWO CONVERGING LINES AB AND AC. Bisect the angle BAC by the line AD. From any point E in AD draw a perpendicular to AB. With E as centre and EF as radius describe the circle touching AB and AC. Through G (the intersection of the circle with AD), draw HK tangential to the circle. Make KL equal to KF, and at L erect a perpendicular to AC, cutting AD in M, which is the centre of the next circle. Proceed in a similar manner for other circles as shown.

OBJECT DRAWING

For further practice in training the eye, and to show how to analyse an object to find a simple system of construction for drawing it correctly, we will explain the geometrical models called the hexagonal and octagonal prisms.

The Hexagonal Prism. This object has a regular hexagon for each of its ends, and oblongs for each of its other surfaces, but both shapes will, of course, vary infinitely *in appearance* according to the point of view from which they are seen. In **217** (which is the appearance of the prism when the student is directly opposite the end, but the object below the eye level), a system of construction lines (dotted), will be noticed—viz., AD, which is parallel to BC and EF; also BF and CE, *vertical* lines through B, F, and C, E, respectively. If GH is bisected in K, it will be seen that there are *four equal parts* along AD—viz., AG, GK, KH, and HD. These, of course, will not appear equal when the object is placed in such positions as represented in **218–224**.

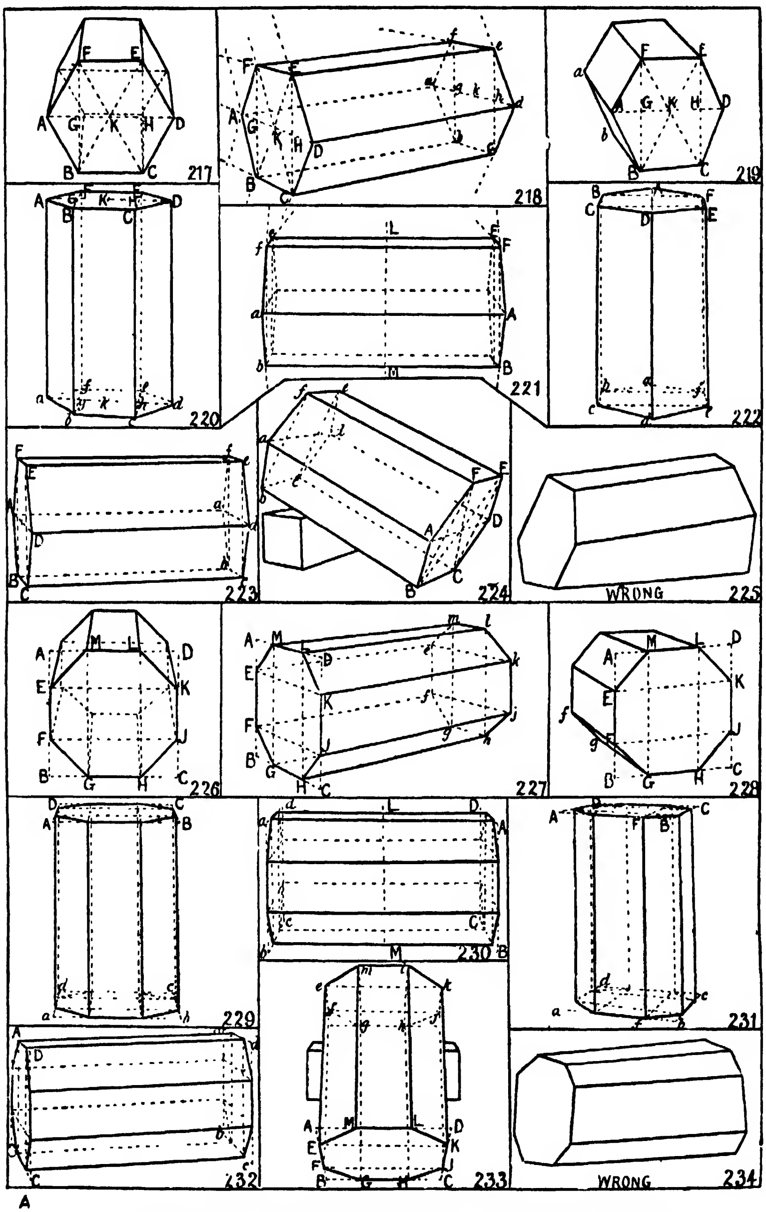
A view as shown in **218** is a good one from which to learn the method of drawing this object. Begin by determining the position of the corner C with relation to surrounding objects, then the direction of apparent slant of the edges BC and Cc and their respective apparent lengths. From B, C, and c draw vertical lines BF, CE, and ce, and determine the relative height of CE. Through E draw Ee converging with Cc, and EF with CB. Bisect CE in H, and BF in G. Through G and H draw AD converging with both CB and EF. Fix the position of K by drawing the diagonal BE. Make HD slightly—very slightly—longer than KH, and AG very slightly shorter than GK. The student should consider carefully why these are apparently different lengths, although in the object really the same.

Join AB, CD, DE, and FA, which will complete the apparent shape of the nearer end of the prism. Through D, E, and F draw lines converging with Cc. The line Ee intersecting with ce determines the height of ce. Through c draw dc converging *downwards* with DC, and through e draw de converging *upwards* with DE, and ef converging with EF, thus completing the drawing. The dotted lines at the further end are put in to show the full construction, and that again we have an instance of the further end being *apparently* slightly wider from a to d than from A to D at nearer end, but of course (owing to the convergence of Ee with Cc) the length of ce is shorter than CE. The foregoing method is somewhat mechanical, but if the student will make careful observation from the model, he will find the method an excellent proof of the accuracy, or otherwise, of his capacity of judging apparent lengths, etc., or of guiding or even compelling him to see the true apparent sizes, etc., of the object.

In **218** it should be observed that there are *four* directions of convergence: first Cc, Dd, Ee, and Ff converging to the right; second, CB, DA, EF and ef to the left; third, DC, FA,

and *dc* downwards to the left; and fourth, *DE*, *BA*, and *de* upwards to the left. Compare **218** with **225**, which is an incorrect drawing of the same view, showing the many usual errors made by beginners. Intelligent consideration should be given to ***why*** **225** is wrong in so many respects. The student should place the object as indicated in **218**, and make careful tests.

In **220** and **222** notice how *BA*, *DE*, and *ab* converge with one another; also *AF* with *CD* and *cd*; and *CB* with *EF* and *cb*. Fig. **221** shows the representation when the observer is directly opposite the dotted line *LM* and the object below the eye level. Notice the ***three*** sets of converging lines, and that *AB* is apparently smaller than *AF*, and *FE* much smaller still. In **219** observe the peculiar apparent shape of the face *ABba*. A view like that shown in **223** often gives considerable difficulty to beginners owing to very much foreshortening of the visible end, but it is constructed just like **218**. Fig. **224** is also rather difficult because of the tilting of the object, but keen observation of the model will enable the student to overcome such difficulties. Notice that the corners *E* and *F* are not *vertically* above *B* and *C* respectively, and that the construction lines *FB*, *EC*, *fb*, and *ec*, converge *downwards*. There are also, as in **218**, *four* directions of convergence.



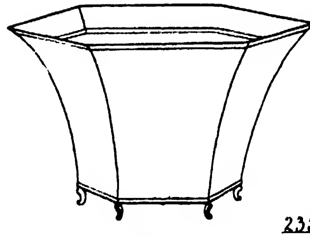
A LESSON IN THE HEXAGONAL AND OCTAGONAL PRISMS

The Octagonal Prism. This model has a regular octagon at each end, but oblongs for each of its other surfaces, and both shapes may have an infinite number of appearances from different points of view. Fig. **226** is an end view, and shows how the regular octagon may be enclosed in a square *ABCD*. Then, if the relative sizes of *BG* and *GH* are determined the construction is easily made, for *AE*, *AM*, *BF*, *BG*, *CH*, *CJ*, *DK*, and *DL* are all equal in this view. Draw the construction lines as indicated.

Fig. **227** gives the usual system of guide lines. First determine the position and distance apart of the vertical lines *AB* and *CD*, and obtain the apparent height of *CD*. Draw *CB* and *DA* converging at the correct angle towards the left, thus completing the *apparent shape* of the skeleton square *ABCD*. Then by

careful comparison fix the positions of the points G, H, J, and K, and through each draw the respective construction lines, which at certain intersections give the positions of the corners of the octagon's *apparent shape*. Join these corners by the lines as shown. The completion of the drawing needs only care in observation as regards proportion and convergence of certain edges. Fig. **227** should be compared with the *incorrect* drawing shown in **234**, which contains very many errors usually made by careless observers. By intelligently criticising a bad drawing, and finding out why it is wrong, a student may sometimes learn more about the correct way it should be drawn than if he merely looked at a true representation of it; and, moreover, certain principles will be more deeply impressed upon his mind.

There is no need to give detailed explanations of the other representations of the octagonal prism as shown in **228-233**, as the drawings, with the dotted construction lines, speak for themselves as regards the method to be used in obtaining the various apparent shapes. The student must place the prism as indicated and *draw from the object*. Fig. **229** is the appearance when the student is opposite the front face but the object below the eye level. Fig. **230** gives the representation when viewed from a point opposite the line LM. Fig. **231** shows how the drawing should be made when seen from a point practically opposite the edge Ff. Fig. **232** shows the drawing of the difficult view when the near end is much foreshortened, while **233** is perhaps more difficult still, as the object is tilted upwards directly away from the observer, and particular attention should be given to the foreshortening of the near end, as well as the correct direction of convergence of certain edges.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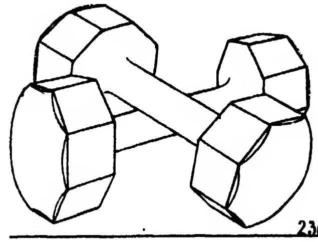
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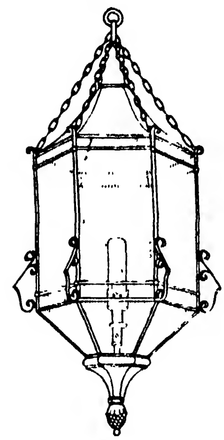

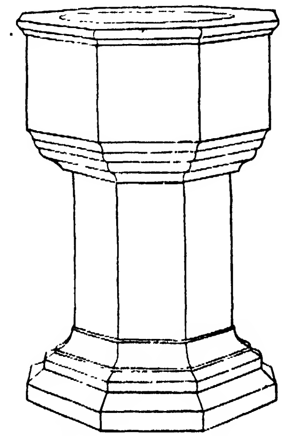
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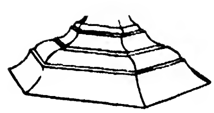

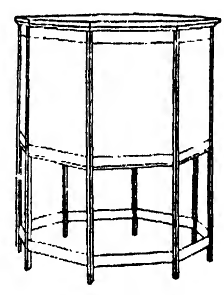
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OBJECTS DRAWN ON THE SAME PRINCIPLES AS THE HEXAGONAL AND OCTAGONAL PRISMS

Application of the Principles in this Lesson. It is sometimes difficult to obtain objects which are hexagonal or octagonal in shape, but drawings are given in **235-237**, **239**, and **240**. The objects should, in some cases, be placed lying over on their sides, so as to give further practice in drawing difficult views, and to give opportunities for improving the powers of observation to a higher level of excellence.

Continued

FORCE OF GRAVITY & ITS PHENOMENA

Specific Gravity and the Methods of its Determination. The Hydrometer and Specific Gravity Bottle. Equilibrium

Continued from page 664

By Dr. C. W. SALEEBY

The Force of Gravity. Before we consider the importance of gravitation in relation to the world as a whole we must pay some attention to the facts of gravitation as they are witnessed at the surface of the earth. The first thing to determine, if possible, is the intensity of the force of gravity at the earth's surface. We may measure this by measuring the acceleration which gravity produces on any body free to move under its action alone. The size of the body which we choose for observation is of no importance ; the same acceleration will be produced, as we saw in the first chapter, whether we choose a feather or a piece of lead. We have already stipulated that we are to observe the force of gravity alone, and therefore the resistance of the air must be excluded.

The student is sometimes puzzled to understand how it is that the acceleration is the same whether we choose a massive body or a "light" one. He argues that the force of gravity is proportional to the mass of the mutually attracting bodies ; if, therefore (he says), the mass of the body we study be increased, surely the resulting force will be greater, and therefore the body will fall with greater rapidity ? Now, until the last clause the student is quite right ; certainly, when we increase the mass of the body we examine, the force of gravity will be increased, but it is increased exactly in proportion to the work it has to do. In the case of the small body, it has to move only a small amount of matter ; in the case of the more massive body it has to move a much greater amount of matter, and its force is exactly proportional to the mass of matter in question ; hence the velocity which is imparted to the two bodies is precisely the same in both cases.

Now, it is possible to determine the intensity of gravity by allowing a body to fall and observing the velocity which it has gained in a second, but this method is exceedingly difficult, unless we are to be contented with a very rough estimate.

The method usually chosen depends upon the fact that the period of vibration or oscillation of a pendulum depends strictly upon the dimensions of the pendulum and the intensity of gravitation. Experiments with a pendulum are capable of great delicacy of observation.

The Value of Gravitation. The intensity of the force of gravitation—that is to say, of the earth's gravitation—is symbolised in physics by the letter "g." The value of "g" varies in different parts of the world, for the earth is not a true sphere, and thus different parts of its surface are at different distances from the centre. In the British Isles the value of "g," as determined by the direct method, by pendulum experiment, and by other means, is about 32·2 ft. per second per second. This phrase is somewhat confusing at first, the repetition of the phrase "per second" seems stupid, but in point of fact it is quite sensible. The assertion is that gravity produces during every second of its action an acceleration of 32·2 ft. per second—that is to say, its force is equal to an acceleration of 32·2 ft. per second per second. It need hardly be said that gravity does not act intermittently, but continuously ; we use the period of a second merely for convenience. The value of "g" at the Equator is less than 32·1 ; at the Poles it is about 32·25. This is equivalent to saying that a body is heavier at the Poles than at the Equator. The value of "g" at the Equator (more precisely represented by the figures 32·091) is less than the figure at the Poles in the first place because, owing to the shape of the earth (which is a sphere flattened at the Poles, or an oblate spheroid), a body at the Equator is more distant from the earth's centre than the same body at the Poles ; and, secondly, becau e of the centrifugal force at the Equator, due to the earth's rotation, which tends to hurl the body outwards, and so diminishes the apparent force of the earth's gravitation.

Specific Gravity. More for the sake of convenience than because the subject has a logical place here, we must now discuss the question of specific gravity. The word gravity is here used in a slightly different sense to that which has preceded. The word specific in this phrase is used in a sense frequently employed in physics, as for instance, in the phrase *specific heat*. This specific gravity is the representation of the amount of stuff contained in any substance in proportion to the volume of the substance taken ; hence it is merely a measurement of the massiveness of the substance. Most of us, in our day, have been puzzled by the question: Which is the heavier, a pound of feathers or a pound of lead ? Of course, by the definition, they are both of the same weight, but their density is very different ; and this gives us the key to the meaning of specific gravity, though of course no one would attempt to determine the specific gravity of feathers. For convenience, it is necessary to have some standard by which to compare all substances, and this standard is furnished us by water.

Distilled water is taken at the temperature of 4° C., which is its temperature of maximum density. If, now, we compare the weight of a given volume of any substance with the weight of an equal volume of water at this

temperature, we obtain a figure or ratio which is known as the specific gravity of the substance we are examining.

Density. Let us now consider *density*. The *absolute* density of a substance means the amount of matter contained in a unit volume of that substance. Hence, if "m" be the mass, and "v" the volume of the substance, then its density will be equal to $\frac{m}{v}$: but when we determine specific gravities, we are determining *relative* densities. But it is sufficient for our purpose to make only relative measurements, though what we really want to get at is an absolute measurement of the actual amount of stuff the substance contains in a given space or volume. The reason why the relative measurement suffices is that, as Newton proved, the mass of a substance, or the quantity of matter in it, is proportional to its weight; hence, if we take the weight of a unit mass of water at its maximum density (*viz.*, when it has the temperature above stated) as unit density, then the specific gravity of the substance will be identical with its density. This proposition may be stated in abstract terms thus. The relative specific gravity of any substance is an accurate measure of its absolute specific gravity, and thus of its density. All these propositions depend upon the Newtonian proof that weight is proportional to mass.

Determination of Specific Gravity. This offers no difficulties in the case of regularly-shaped bodies which we can weigh by the usual means—the balance or the spring. But this method will not suffice unless the body is of such a shape that we are also able accurately to determine its volume. When a body is of an irregular shape, it is impossible by direct measurement to ascertain its volume—that is, the amount of space it occupies. It was the great discovery of Archimedes that enabled us to ascertain without difficulty the volume of an irregular body by immersing it in water, and observing the degree to which the water rises. This is what he did with Hiero's crown. Not only so, a body which is wholly immersed in water loses a part of its weight, which is exactly equal to the weight of the water which it displaces; hence, by weighing the amount of displaced water we readily ascertain the weight of water equal in volume to any body.

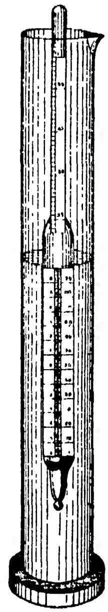
The Hydrometer. The instrument for obtaining the specific gravity of a liquid is the *hydrometer*. The principle of this instrument is known as "Archimedes' principle," which may be thus stated. *When a body is wholly or partly immersed in a fluid, it loses in weight an amount equal to the weight of the displaced fluid.* The common hydrometer consists of a weighted and graduated glass tube, which is suspended in the liquid to be tested, and the depth to which it sinks or the level at which it floats indicates the specific gravity of the liquid. Upon the stem of the hydrometer there is marked the point to which it would sink in distilled water at 4° C. If the liquid be heavier than water, the hydrometer will float at a higher level, and *vice versâ*. A great improvement is now effected in the common hydrometer by adding to it a thermometer in the stem. Thus the reading which it affords is a reading of the specific gravity of the liquid at the temperature simultaneously indicated by the thermometer. This is an important matter, since the specific gravity of a liquid varies with its temperature. As a rule, the addition of heat to a liquid increases its volume, or rather, the ratio of its volume to its mass—that is to say, it lowers its specific gravity.

Density of Water. A remarkable exception to this rule is furnished by water. When heat is added to water, at, say, 1° C. (just above freezing-point), the water does not expand, but contracts; it goes on contracting until the temperature of 4° C. is reached. If the temperature be raised beyond this point, the water starts to expand again, thus behaving like all other liquids beyond this point. This peculiar property of water—in virtue of which ice is lighter than water of 1, 2, 3, or 4° C.—is one of the most important physical properties of this exceedingly important substance. If water behaved according to the ordinary rule, ice would naturally be heavier than liquid water of any temperature, and would therefore sink, whereas, as we know, it floats. This is very fortunate, for otherwise the ice formed in cold weather would sink to the bottom of lakes or seas, which would thus be gradually piled up winter after winter by successive layers of ice; but in virtue of the fact that ice, in defiance of the general rule, has a lower specific gravity than water of a higher temperature than its own, it floats, and thus the sun's rays—when their strength returns—are able to melt it. Human life would be impossible were it not for this one property of water alone.

The hydrometer is very widely used in various forms. It is constantly employed by the brewer and the exciseman, who usually call it an alcoholometer, since their purpose is to ascertain the strength of a spirit. When it is used to ascertain the quality of milk, it is called a lactometer. The greater the amount of solid matter dissolved in the milk, the greater is its specific gravity. Similarly, the physician desires to test, by means of the hydrometer, the specific gravity of many of the bodily fluids.

Specific Gravity Bottle. But there are other cases where other means of ascertaining the specific gravity of a substance have to be employed. There is, for instance, what is called the *specific gravity bottle*, sometimes used for liquids, sometimes for solids. The bottle is constructed to hold precisely a thousand grains of water at the temperature now familiar; and the stopper of the bottle has a hole through which the contents can ooze when the stopper is driven home. Supposing, now, we wish to ascertain the specific gravity of small shot, we take a given weight of the shot and insert it in such a bottle already filled with water. The amount of water that escapes from the bottle in order to

make room for the shot is equal in volume to the shot inserted. We have already weighed the shot, and we now weigh the water displaced by it. The ratio of the first weight to the second is the specific gravity of the shot. Similarly, we may ascertain the specific gravity of a fluid which is lighter than water. If, for instance, we find that we can squeeze only 715 grains of ether into a bottle which will hold 1,000 grains of water at the same temperature, we are able to state that the specific gravity of ether is ·715, the specific gravity of water being taken as 1. For convenience we usually use 1,000 instead of 1, and adapt our other measurements to this figure; thus, the specific gravity of human blood is 1055, of ether 715, and so forth. [See below.]



HYDRO-METER

In order to obtain perfect results it would be obviously necessary to have constant temperature, and to have the pressure of the various gases within the globe always the same.

Here follows a list of some important specific gravities:

Solids.

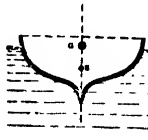
Platinum (rolled)	22·1	Diamonds ..	3·5
Gold	19·3	Marble ..	2·8
Lead	11·4	Aluminium	2·7
Silver	10·5	Ice	0·9
Iron (wrought)	7·8	Potassium ..	0·9
„ (cast) ..	7·2	Lithium ..	0·6
Tin	7·3	Cork ..	0·2

Liquids.

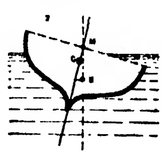
Mercury ..	13·59	Sea water ..	1·03
Sulphuric acid	1·84	Petroleum ..	0·84
Blood	1·05	Alcohol ..	0·79
Milk	1·03	Ether ..	0·71

In the "Encyclopædia Britannica," Vol. 12, page 541, the reader will find several hundreds of precise measurements of the densities of various bodies.

Specific Gravity of Gases. Lastly, as to specific gravity of gases. The ascertaining of this is a matter of more difficulty, but it follows the same principles. Our business is to determine the relative weight of the gas in question and of air; much better, however, is to take the lightest known gas—*viz.*, hydrogen—instead of air as our standard of comparison for gases. Relatively to hydrogen, the specific gravity of air is about 14·4, and of oxygen 16. One method of finding the specific gravity of a gas may be quoted. It consists in successive weighings of a brass globe to which an air pump can be attached. The globe is weighed when all the air has been extracted from it; it is weighed when full of air, and when full of the gas we are examining. Thus we ascertain the weight of the air and the weight of the gas, and thus the specific gravity. If we are using hydrogen as our unit, we will fill the globe, not with air, but with hydrogen.



1



2

Centre of Gravity. This is another term which must be dealt with here, though its treatment involves an interruption in our study of gravitation in general. The term *centre of gravity* is itself open to criticism. A much more correct term is centre of mass or centre of inertia. It may be defined as that point about which two or more particles are in equilibrium. We have already discussed the question of equilibrium, and seen that it depends upon an equality in the moments of the forces. Now in every body there is a point about which it will balance, and this point we call its centre of gravity. Some bodies are such that their centre of gravity is really central, and these are called *centrobaric* bodies. In the case of a sphere, for instance, whether solid or hollow, the force of the earth's gravity acts upon it, no matter in what position the sphere be placed, just as if all the matter of the sphere were condensed at its centre; and that centre is its centre of gravity. A rectangular plate, again, will be balanced by a thread supporting it at the point where its two diagonals intersect one another; but in the case of irregular bodies the position of the centre of gravity cannot be so readily ascertained.

Now, we have said that the centre of gravity is the point where the whole weight of the substance may be considered as massed; the body will be in equilibrium if this point is supported. Let us, then, pick up an irregularly shaped plate of which we desire to ascertain the centre of gravity. We hang it up by a string attached to it at one corner, and we find that it assumes a certain position. If we prolong downwards to the earth the line of the string, we may be certain that the centre of gravity will lie in that line, for we have said that the centre of gravity is the point around which the whole substance of the body might be supposed to be massed, and upon which the earth's attraction acts; hence, the centre of gravity must lie immediately under the supporting string since then we will have the earth's attraction acting downwards and the tension of the string acting upwards in the same straight line, the two forces neutralising one another so that the plate hangs steadily or in equilibrium. If, now, the plate be hung up at another point and a line be drawn upon it in continuance of the line of string, the centre of gravity must correspond to the only point which this line and the previous one have in common—*viz.*, the point where they cut one another.

Equilibrium. We are now in a position to add somewhat to the remarks already made on the subject of equilibrium. We said that a body is in a state of stable equilibrium when it tends to return to its original position after the temporary application of a disturbing force, whereas it is in a state of unstable equilibrium when the temporary application of any new

force causes a permanent change in its position. We also said that the conditions of stable equilibrium are satisfied when a vertical line dropped from the centre of gravity of the body in question falls within the area of ground formed by joining all the points at which the body is supported. But having considered the question of gravity at further length, we are now in a position to state the law which determines the difference between unstable and stable equilibrium, and which also brings the fact of neutral equilibrium into relation with them.

We may say that a body is in stable equilibrium when any displacing force tends to raise the centre of gravity. It is in unstable equilibrium when a disturbing force tends to lower it. This law is intelligible now, but it would not have been so before, for we have come to regard the centre of gravity as that point at which the whole weight of the body may be supposed to be concentrated. Hence the force that tends to raise the centre of gravity is doing work against gravitation, and, when the force ceases to act, gravitation (which never ceases to act) pulls the body back to its original position; hence its equilibrium is stable. On the contrary, the displacement which lowers the centre of gravity is a displacement which gravitation favours; and when the displacing force is removed the body shows no tendency to return to its former position; there is no force to make it do so.

The Illustration of the Egg. Let us take the illustration of the egg. The egg may be balanced for a moment on its point, but its equilibrium is unstable because any displacement involves a lowering of its centre of gravity. If, now, the egg be rested on its side we may consider the case of displacing forces applied to it in two directions. The egg may be rolled along the table by a push applied to it at one side. When friction and the resistance of the air have arrested its movement, the egg will come to rest. It is in a state of neutral equilibrium, for, assuming that the yolk of the egg is centrally situated, the centre of gravity of the egg has neither been raised nor lowered by this displacing force. If, however, we attempt to tilt up the egg by applying the finger at one end, we find that so far as such a force is concerned the egg is in a state of stable equilibrium, for now we are attempting to raise its centre of gravity, and as soon as the displacing force is removed the egg returns, after a few oscillations, to that position of stable equilibrium in which its centre of gravity is as low as possible—that is to say, the position the retention of which is favoured by the whole force of gravitation.

Equilibrium in Boats and Ships. This principle is not infrequently a matter of life and death. Let us take, for instance, the case of accidents in a rowing boat. Why should the stability of a boat be affected when one of its occupants rises? Why should fatal accidents often occur when two of them rise at once? The answer is that the centre of gravity of the whole system, boat and contents, is raised, and it is of course raised higher when two of the occupants are standing than when one only is standing. The higher the centre of gravity of the system, the more likely is a slight oscillation or displacement to swamp it.

Let us now take the case of a floating ship. It has its centre of gravity; it also has what is known as the centre of buoyancy*, which is the centre of gravity of the water which is displaced by the ship. The weight of this displaced water is one of the forces acting upon the ship, and it acts upon the ship at the centre of buoyancy. Now, when the ship is floating on an even keel, its centre of gravity is above its centre of buoyancy, but the two are in the same vertical line, which is the middle line of the ship [1].

Now, when the ship is tilted [2] its centre of buoyancy is shifted to one side of the centre of gravity. The weight of the ship acts still through the centre of gravity [G], whilst the re-active pressure or buoyancy of the displaced water acts vertically upwards through the new centre of buoyancy [B], in a line which cuts the middle line of the ship at the point M; this point is called the *metacentre*. The essential for the stability of the vessel is that the metacentre be above the centre of gravity; so long as this is so the weight of the ship and the buoyancy form what is called a *couple*, which tends to right the vessel. If the metacentre were below the centre of gravity, the couple would tend still further to roll the vessel over Hence, a ship must be so constructed that when she is displaced the centre of buoyancy comes to be at some distance from the middle line, and the metacentre well above the centre of gravity. The object of putting ballast in a vessel is to lower the centre of gravity. The removal of the ballast is thus equivalent in result to standing up in a rowing boat.

* This is situated, of course, nowhere in the displaced water, but at some point in the ship.

Continued

RAILWAY AND MINE SURVEYING

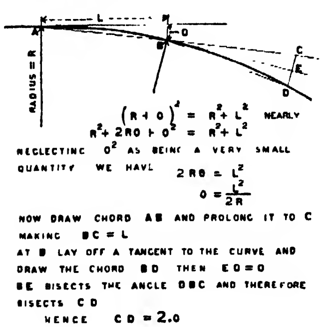
Setting out Curves and Sidewidths. Explanation of the Use of the Clinometer and Circumferentor

Continued from page 712

By Professor HENRY ROBINSON

IT is now proposed to explain a few methods of surveying more or less applicable to particular branches of work.

Railway Surveying. The details necessary for preparing plans and sections of a proposed railway line in this country are dealt with in another course, on PARLIAMENTARY SURVEYING. The subject of railway surveying is itself a large one, embracing as it does the preliminary survey, or reconnaissance, for a railway in unexplored countries, where the maps, if any exist, are inferior, to making the final survey and setting out the line. The positions of the centre lines with regard to one another, and taking the levels in order to fix the gradients of the line, are carried out by the methods already explained. It must be assumed for the purposes of this course that the general route is determined, and that it is necessary only to fix the position of the centre line of the railway, to fill in the curves, and to peg out the positions where the banks and cuttings will appear on the surface of the ground.



50. CHAIN AND OFFSET METHOD

In this country, where the Ordnance maps are good, and contour lines are shown, a sufficient approximation as to the general route can very often be made from them, with perhaps a few levels at the most important points, care being taken to interfere as little as possible with existing works. The main point is to get the most direct route with as little cutting, embankment or tunnelling as possible, without sacrificing directness from point to point. If cutting be necessary it should as nearly as possible equalise the stuff required for embankment. The steepness of the gradients and the sharpness of the curves must depend to a great extent on the purposes for which the line is to be employed.

In the event of the ends of two lines having to be joined by curves, one of the three following methods may be employed:

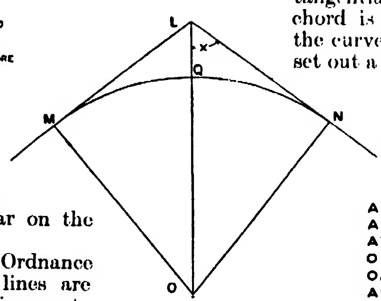
1. With chains and offsets
2. With theodolite and chain.
3. With two theodolites.

Chain and Offset Method. One method with chain and offsets is sufficient, and is shown by **50**. The point at which the curve commences is called the *tangent point*, and is shown at A. A length, L, is set off along the tangent line, and an offset O (calculated as shown in the illustration), is measured, meeting the line AB at B. AB is made equal to L. The method of fixing the point B is to pin down one end of the chain at A, and one end of the offset at the end of L. The chain is then swung away until the other end of the offset and the chain, when quite tight, coincide, which fixes the point B, or the first point on the curve.

The bottom part of the figure shows how all succeeding offsets are taken, and that the second and all following offsets are twice the first one.

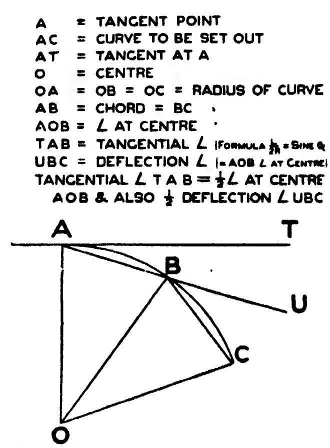
Theodolite and Chain Method. The simple method of ranging railway curves by means of *tangential angles*, set out by the theodolite and chain, will now be treated.

The illustration [**52**] gives the relations between the various factors in calculating the tangential angle. The length of the chord is called L and the radius of the curve R. When it is required to set out a curve of any particular radius between two straight lines it is necessary to find first the two tangent points at which the curve starts. The production of these two straight lines results in their intersecting at a point where the *angle of intersection* may be observed.



51. SECOND METHOD

Referring to **51**, LM and LN are the tangent lines which intersect at



52. TRIGONOMETRICAL RELATIONS

LENGTH OF TANGENT

$\angle MLN = \angle$ OF INTERSECTION

$\angle MLO = \frac{1}{2}\angle$ „ „ $= x$

$\frac{OM}{ML} = \text{TAN.}\,x \qquad OM = r$

$ML = $ TAN.

$\therefore$ LENGTH OF TAN. $ML = \frac{r}{\text{TAN.}\,x}$ OR $r \cot x$

DISTANCE FROM POINT OF INTERSECTION TO MIDDLE OF CURVE = LQ

$LQ = LO - OQ \qquad \frac{LO}{OM} = \text{CO-SEC}\ x$

$\therefore LO = OM \operatorname{cosec} x$

$= r \operatorname{cosec} x$

HENCE $LQ = r \operatorname{cosec} x - r$

$= r(\operatorname{cosec} x - 1)$

53. LENGTH OF TANGENT, ETC.

the point L. M and N are the tangent points, and MLN the angle of intersection. MQN is the curve to be set out. OM = ON = radius of the curve. The method of calculating the lengths of the lines LM and LN is shown in 53.

The calculated length of the tangent line is set out each way from the point of intersection L [51], and stakes are driven in at the tangent points M and N. Next we must find Q [51]. The method of calculating this is shown on the lower part of 53. This point is set out with the theodolite by bisecting the intersection angle, and ranging it in with the instrument. It is usual to set out part of the curve from each tangent point to minimise errors of lateral deviation, pegs being put in at equal intervals all along the curve or centre line of the railway, say at every chain. If these pegs are kept at the even chains it follows naturally that the tangent point rarely coincides with one of the chain pegs, and therefore the *first peg* at each end is only a fraction of a chain from the tangent point. It therefore becomes necessary to calculate the length of the curve in order to make the pegging out from both ends coincide in closing in the curve. The method of doing this is shown in 54, and serves as an excellent check on the work.

It now remains to be seen how these various factors are set out. The theodolite, after being used at L for finding the intersection angle, and the middle point of the curve, is removed to M or N, and after being set up, is sighted on to L, and the first tangential angle is taken. One end of the chain is then fixed at the tangent point, and the other end is moved until the cross hairs of the theodolite cut the peg held at the end, which gives the first point on the curve. The next angle is then set out equal to twice the first, one end of the chain is held at the peg just fixed, and the second point is found.

It often happens that some obstacle, such as a wood or hill, prevents the whole of a curve being set out from the tangent points. Fig. 55 shows how to range a new tangent point from any point on the curve.

LENGTH OF CURVE MQN = l

RADIUS = R

$\angle$ OF INTERSECTION $= 2x$

CIRCUMFERENCE OF A CIRCLE $= 2\pi r$

„ „ QUADRANT $= \frac{1}{4} \times 2\pi r = \frac{\pi r}{2}$

i.e. LENGTH OF CURVE SUBTENDING $\angle$ OF $90° = \frac{\pi r}{2}$

$\angle MON$ SUBTENDED BY CURVE $MQN = 180° - MLN$

„ „ „ „ $= 180° - 2x$

THEN

$l : \frac{\pi r}{2} :: (180° - 2x) : 90°$

$l = \frac{\pi r}{2} \times \left(\frac{180° - 2x}{90°}\right)$

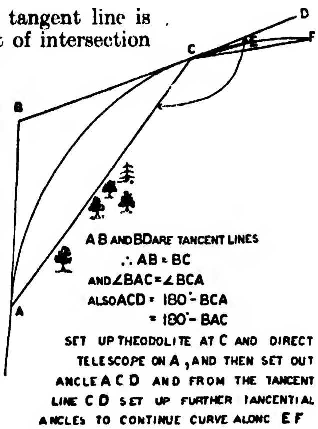
$l = \pi r \times \left(\frac{90° - x}{90°}\right)$ AND $90° = 5400'$

$\therefore l = \frac{\pi r\,(5400' - x)}{5400'}$ BUT $\frac{\pi}{5400} = \cdot 000582$

HENCE $l = \cdot 000582 \times r\,(5400 - x)$

x BEING IN MINUTES

54. LENGTH OF CURVE

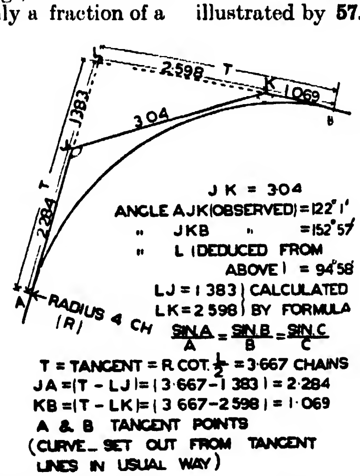


55. PASSING OBSTACLES

The point of intersection is frequently not accessible, so that its position has to be calculated trigonometrically, and the tangents determined in the same manner. Fig. 56 shows how this may be done.

The directions of the tangent lines are known. Any two points, J and K, are chosen, and the distance chained. The distances JA and KB are calculated, as shown in the illustration. They are then chained, and the tangent points A and B fixed. The curve is then set out as explained previously.

Method by Two Theodolites. The third method of setting out curves by two theodolites, one set up at each tangent point, is illustrated by 57.



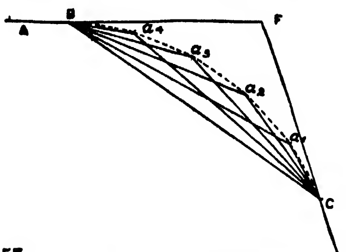
56. INTERSECTION POINT INACCESSIBLE

B and C are the tangent points. The telescope of the theodolite at B is directed to C, and the tangential angles set out from BC, while the tangential angles are set out from CF by the theodolite at C. The intersection of these angles fixes the various points on the curve, as A_1, A_2, etc.

After pegging-out the centre line of a railway, the "side widths," as they are termed, have to be set out to indicate the ground that will be occupied by banks or cuttings when the line has been constructed, which will depend on the depth of the cutting, or the height of the bank, and the ratio of slopes of the sides.

Fig. 58 shows a practical method of doing this. The point C is the centre of this particular section. It is required to find out where the side slopes of the cutting will cut

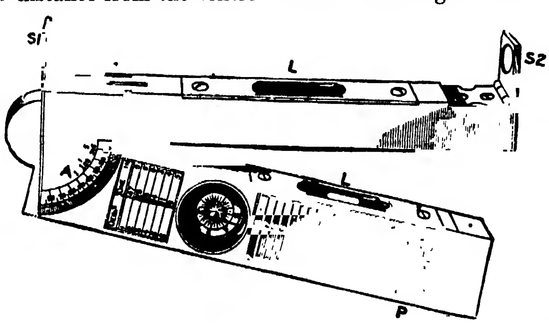
the surface of the ground. First assume the ground to be horizontal as HC, and compute the half width. In the illustration this would be 18 ft. for the half formation width (AB), and 40 ft. for the slopes (for a depth of 20 ft. with slopes of two to one), making altogether 58 ft. It is obvious that, for sloping ground, this width will be greater on one side than on the other. Taking the lower side, an approximate point is chosen and fixed by measuring down the slope some distance less than 58 ft. The difference of level of this point and the centre point C is found. This difference of level multiplied by the ratio of slopes (2 to 1) will give a figure to be subtracted from the calculated 58 ft. to give another trial point. One or two trials will generally suffice. In the case of the uphill side, the amount found by the difference of level of C and some chosen point greater than 58, multiplied by the ratio of the slopes, must be added to 58.



57. TWO THEODOLITE METHOD

As an example, let us suppose that the staff had been held at E, the correct point, and that the distance measured was 54 ft; then the difference of level between C and E was 2 ft. This multiplied by the ratio of slopes (2 to 1) = 4 and 58 − 4 = 54, the point already chosen. In the case of embankments the exact opposite would occur, as the toe of the bank would cut the uphill side at a less distance from the centre line than the downhill side. An instrument which is useful for determining the slope of the ground is the Clinometer.

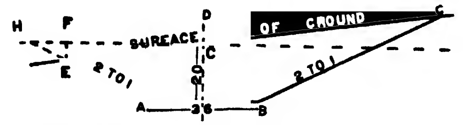
Clinometer. This useful hand instrument [59] is for determining the slope of the ground or the angle it makes with the horizon. From the illustration it will be seen to consist of two arms jointed at one end and provided with spirit-levels (L), the top arm having "sights" (S1 and S2), through which the inclination is observed. The value of the inclination in degrees is taken from the graduated scale (A), and the gradient is directly obtained from a table (P) marked on the side of the lower arm.*



59. CLINOMETER

* For example, a reading on the scale A = 6° the gradient will be found from the table (P) to be 1 in 9·5. On the reverse side of the lower arm is a table giving the rise in inches per yard for angles up to 45°.

Mine Surveying. In carrying out surveys underground a few special arrangements have to be adopted to ensure that accuracy which is of the greatest importance. The survey is necessary, not only as a record of existing works, but also to enable extensions of the headings and workings to be planned with regard to the minerals to be mined. In mines in this country the chain of 66 ft. is usually employed for measuring the survey lines, which are fixed by means of traversing. In making underground surveys by traversing with the magnetic needle, care must be taken that no disturbance of the needle is caused by the proximity of metalliferous substances, either the ore to be extracted, or rails, trolley lines, etc., in the workings. Where such causes of disturbance exist, the lines have to be set out by angular observation rather than by magnetic bearings. An instrument that has been employed largely for underground traversing is the circumferentor, or miner's dial.



58. SETTING OUT ON SIDELONG GROUND

Circumferentor. Fig. 60 is an illustration of a circumferentor, or miner's dial, manufactured by Messrs. Troughton and Simms. In the simplest forms the telescope and the vertical limb are omitted, and two vertical vanes, similar to the prismatic compass, are employed instead. The instrument illustrated is capable of being levelled by the screws (L), and the bearings of the lines are read by means of a vernier in the dial (D), which has also a magnetic needle enclosed in it. Vertical angles are read on the limb by raising or depressing the telescope.

Lighting the Lines. Owing to the surveys having to be carried out in the dark, various arrangements have to be adopted for lighting the lines. For long survey lines, a candle flame is the best object to sight, but care must be taken to shield it from draughts. When, however, the lines are short, sights are taken to a plumb-line suspended from the station point. In collieries where the risk of explosion from fire-damp has to be considered, the safety-lamp is employed, and should be supported on a tripod, which can be levelled in order to get it horizontal. In many cases the traffic of trolleys to and from the faces in tunnelling renders it desirable to mark

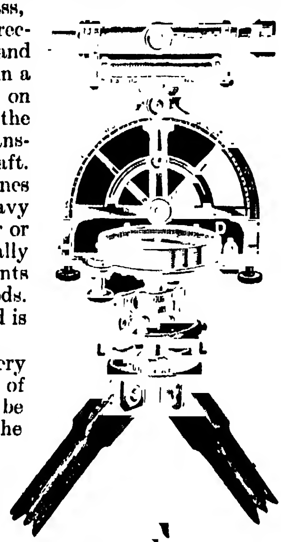
all station points used for the alignment on the roof or overhead timbering, and to suspend plumb-lines therefrom, so that a line can be produced or a sight taken with a theodolite or circumferentor.

61.

FIXING STATIONS UNDERGROUND

Garforth's Method. Fig. 61 shows a device for rapidly suspending a line and adjusting its position precisely under the station point, and was the invention of Mr. Garforth. The plumb-bob is suspended from a terminal carried on gimbals, like a ship's compass, and arranged to move in two directions when operated by rack and pinion gear. The terminal ends in a point, which is directed upwards on to the station mark. One of the most difficult operations is the transference of a base-line down a shaft. The method of using two plumb-lines of steel or brass wire, with heavy weights hanging into tubs of water or oil to retard vibration, is usually adopted. The vertical measurements are made with steel tapes or rods. In inclined shafts the rod method is preferable.

When using a steel tape for very accurate work, the temperature of the surrounding air should be observed, and also the tension of the tape. A spring tension dynamometer attached to one end of the tape affords an easy way of ensuring the same tension at each measurement.



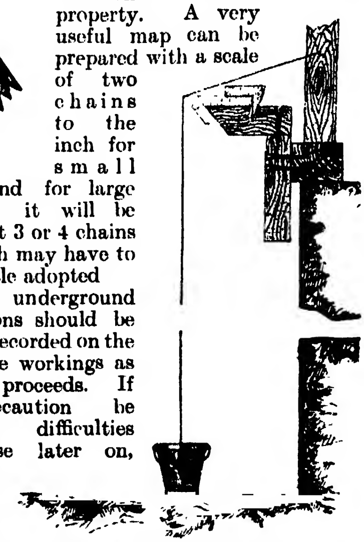
60. CIRCUMFERENTOR

Transferring Stations Below Ground. Fig. 62 shows one method of getting a station from the surface, below ground. By this method a board is firmly nailed to the shaft, and is provided with an iron plate and clips, which are clamped to the board. The plate can be gently moved under the clips by tapping with a hammer. The plumb-line is suspended over the plate, as shown, and its position fixed by ranging it in line by means of a theodolite set behind it, and adjusted on to a point on the line above ground, which it is required to produce below ground. A similar arrangement is fixed on the other side of the shaft, and the line thus set out can be produced below ground. Great care is necessary in producing these lines, on account of the shortness of the base available. In the event of there being two shafts connected together, a plumb-line can be taken down each, and the station at the bottom fixed. They can then be connected together by traversing both below and above ground. When taking sights to a suspended plumb-line, it is necessary that all vibration should have ceased. The sight must be kept on the wire for some length of time, in order to be certain that the point is the correct one and not some other than the vertical taken up by the very slow vibration of the wire that is nearly imperceptible except by long observation. Iron plumb-bobs have been known to be drawn by induced magnetism in iron in the vicinity, and to make the line leave its vertical position. This can be prevented by using brass bobs.

As an instance showing how errors may occur through the transference of lines down deep shafts, the following is an extract from an article in the "Engineering and Mining Journal" of April, 1902, on the divergence of long plumb-lines. "The plumb-lines were used to transfer an azimuth from the surface to an underground level, and were 4,250 feet in length. They consisted of No. 24 piano wire, and the bobs were of cast iron and weighed 50 lb. each, the latter being immersed in pails of cylinder oil for the purpose of retarding vibration. Measurements between their upper and lower extremities showed a divergence of 11 ft. After a very thorough investigation, it was found that this displacement was simply due to air-currents. For the above reasons some engineers prefer to employ a form of transit theodolite specially made for this purpose."

The scales adopted for plotting mine surveys will depend to some extent on the size of the property. A very useful map can be prepared with a scale of two chains to the inch for small mines, and for large properties it will be found that 3 or 4 chains to the inch may have to be the scale adopted

All the underground observations should be carefully recorded on the plan of the workings as the work proceeds. If this precaution be neglected, difficulties may arise later on, when such records would have been of great service.



62. TRANSFERRING STATIONS BELOW GROUND

Continued

TONIC SOL-FA SYSTEM

Various Musical Notations. Principles on which the Tonic Sol-fa System is based. Use of the Standard Scale. The Modulator

Continued from page 634

By J. CUTHBERT HADDEN

THE Staff notation of music is the universal notation, the notation of the whole musical world. As such, it can never be superseded. Like the doctor's Latin prescription, it may be read with equal facility in England or Italy, in Germany or Spain. But other musical notations have been devised, just as "universal languages" have been evolved in alleviation of the confusion of Babel. Rousseau, the French author and critic, suggested, but afterwards discarded, a notation in which the notes of the scale were indicated by Arabic numerals. The same principle is the leading feature of the Chevé system, now largely used in France; and in certain essentials the Tonic Sol-fa notation of letters, the subject of the present lessons, corresponds with both. It is practically the only notation (apart from the Staff, of course) which demands to be considered seriously as a real and live factor in musical education, though its use is confined almost solely to England and English-speaking countries. It has a great and growing "literature" of its own; more than a million and a half of children are learning to sing from it in British primary schools, and choral societies and church choirs all over the country owe to it almost their very existence.

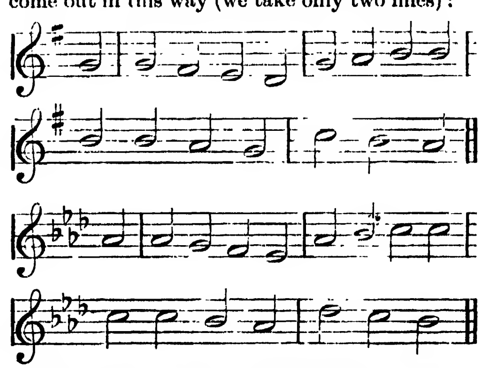
The Founder of Tonic Sol-fa. From his interest in school and congregational singing the Rev. John Curwen was led to take up the subject of teaching to sing at sight. Miss Glover, a teacher at Norwich, had already succeeded in removing from music something of the mystery of sharps and flats, minims and crotchets, and had formed out of her *Do, Re, Mi* diagram a kind of primitive letter notation which the charity children among whom she laboured found no difficulty in reading. Her method of sol-faing differed entirely from that which Mainzer and Hullah taught in their popular classes. These masters adopted the common French system of making the sol-fa syllables only substitute names for the fixed notes C, D, E, F, G, A, B. Miss Glover, on the other hand, followed the scientific usage of England, which makes *Doh* always the key-note, whatever the absolute pitch of that note may be.

Her plan, briefly stated, was to teach the thing music, apart from its signs and names, and to delay the introduction to the accepted mode of writing it until the pupil had obtained a mastery of the thing itself. Mr. Curwen had already come to see the shallowness of the parrot method of teaching to sing, and had been trying unsuccessfully to give permanence to his Sunday-school work by imparting to the children a knowledge of crotchets and quavers, clefs, flats, and sharps, etc. These things, he speedily discovered, were too abstruse for young minds—too abstruse even for the great majority of those who desired to sing yet could not be brought to do the thinking necessary to secure their object in the ordinary way. What was needed was a notation which a child might understand—a notation which a child could sing from as readily as he might read his school primer. Mr. Curwen had been looking for just such a notation, and when Miss Glover's method was brought under his notice he hailed it with delight as being the very thing he desired—easy to teach and easy to learn. As yet, however, it was only a crude idea. It required many modifications and additions—required, above all, to be systematised—in order to perfect it as a notation, as a method of teaching music. Mr. Curwen set himself enthusiastically to the work. He devoted, in fact, the remainder of his life to it, and the result was the Tonic Sol-fa notation and method as we know them to-day.

In proceeding to a study of the Sol-fa notation, we are brought at once face to face with its essential principle. That principle is that there is in reality but one scale in music; that to singers "one key is the same as another." Singers, let it be insisted, were Mr. Curwen's first consideration. His notation was specially devised for them, and although those who learn it can readily play from it, the interests of the player have never been put by the heads of the system alongside the interests of the singer.

Well, to the Tonic Sol-fa singer all keys, we repeat, are alike. Whether he is singing in the key of F or in the key of E, his scale is the same. It is always: Doh, Ray, Me, Fah, Soh, Lah, Te.

Doh always represents the key-note, no matter what may be the key of the music. To emphasise this fact, let us borrow for once an illustration from the Staff notation. Suppose we wanted to write the "Old Hundredth," first in the key of G and then in the key of A flat. It would come out in this way (we take only two lines):



Here, though the tune is identically the same in both examples, the notes have in each case

an entirely different position on the stave; moreover, they re affected, in the one case by a single sharp (look at the key signature), in the other case by four flats. To the eye the difference is considerable, to the ear it is practically nothing—merely the difference of half a tone in the pitch. Why, then, says the Tonic Sol-faist, should the singer be distracted by a new set of symbols? This is the great point of the letter notation. It recognises but one scale, so that the two lines of the "Old Hundredth," as shown, would come out respectively as follows:

KEY G. etc.

:d |d :t_1 |l_1 :s_1 |d :r |m :m |m :m |r :d |f :m |r ||

KEY A♭. etc.

:d |d :t_1 |l_1 :s_1 |d :r |m :m |m :m |r :d |f :m |r ||

There is absolutely no difference, it will be observed, except for the one f ct, not tionally unimportant to the singer, of a different key-name.

For this purpose of naming the key the Sol-faist has, like the Staff notationist, to depend upon what is called the Standard Scale of C, with its letter names in their ascending order:

C, D, E, F, G, A, B.

These names represent fixed sounds — that is to say, C is always C, D is always D, and so on, as on the keyboard of a piano. In Sol-fa their sole use is to determine the pitch of the particular *Doh* of a particular tune. Thus, when the indication "Key F" or "Key E" appears, it means that the *Doh* is at the pitch of the F or E of the Standard Scale. In pitching tunes, a tuning-fork is generally used. It sounds the upper C (there are pitch-forks in A), which the singer imitates, and then runs down the scale to the required note. For instance, if the indication is "Key D," you sound the fork, sing C, B, A, G, F, E, D, and repeat the sound of D to the name *Doh*. A speedier method is suggested in the following directions, which we copy from the "Companion for Teachers of the Tonic Sol-fa Method":

B♭	Sound C,	call it	Ray,	then sing	r d.
A♭	,,	,,	Me	,,	m d.
G	,,	,,	Fah	,,	f m r d.
F	,,	,,	Soh	,,	s m d.
E	,,	then sing C B A G F E.			
E♭	,,	call it Lah, then sing l t d'—s m d.			
D	,,	,,	Doh'	,,	r' d—s m d.

At present the student will not quite understand this, but it is best in place here, and may stand for after reference.

Such is the Sol-faist's use of the Standard Scale. For all other purposes he employs his one scale of *Doh*. The names of this scale are an Anglicised form of the old Italian solfeggio syllables:

Si = Te		Mi = Me
Lah = Lah		Re = Ray
Sol = Soh		Do = Doh
Fa = Fah		

The name *Soh* was preferred to *Sol* as being more open, while *Si* was changed to *Te* to avoid having the same initial letter twice in the scale. For purposes of teaching, and for the student's own practice, the scale is laid out on a sort of diagram called the Modulator. This Modulator, reproduced at the side, is, with its various evolutionary forms, to be subsequently explained, the foundation element in all Tonic Sol-fa teaching. To quote Mr. Curwen himself, it "takes the place of the Staff in the common notation. It stands behind every note in the book. From habitual use of it, the mind's eye always sees it there." It is frequently objected to the letter notation that the notes are "all on a dead level," and do not represent to the eye, as does the Staff, the rising and falling pitch of the notes. But the inventor of the notation was undoubtedly within the mark in saying that by early training the pictorial Modulator is fixed in the mind's eye of each pupil, and the notes start into their places in the scale as he looks at them.

THE MODULATOR

$f^{\prime}$
$m^{\prime}$
$r^{\prime}$
DOH'
TE
LAH
SOH
FAH
ME
RAY
DOH
t_1
l_1
s_1

The Modulator represents pictorially the exact intervals of the major scale. Such a scale is formed of an ordered succession of tones and semitones, or, as the Sol-faist calls them, whole tones and half tones. On the Staff there is nothing to show which are the tones and which are the semitones of a scale. On the Modulator the differences are represented by the differing vertical space. Thus, between *Me* and *Fah* and *Te* and *Doh* we see only half the space that is given to other notes. Hence, *Me* and *Fah* and *Te* and *Doh* are the semitonic intervals of the scale; the others, with the wider space between, are the full tones. "The order and succession of the scale is so natural to us," says Mr. Curwen, "that we do not at first feel this discrepancy; but when the attention is called to the point it will generally be perceived." A most important point it is, for the scale tones derive their individuality from the position of these "little steps," as we shall see when we come to speak of the minor mode.

In the accepted method of teaching the pupil to sing from the Modulator, the scale is taken in sections, as it were, these sections representing the consonantal and foundational chords of the scale. There is no running up and running down of the scale in the stepwise order of its notes, a method which indeed is quite useless for all practical purposes. Instead, the pupil first learns to sing the notes of the Tonic chord—*Doh, Me, Soh*—in the various positions in which these notes may be arranged, the octave of *Doh* (the "high *Doh*") being added last. The same process follows with the notes of the Dominant chord, *Soh, Te, Ray*; and the five notes of the scale thus learnt in two sections

are then combined in one section. After that, the seven sounds are completed by exercises on the Subdominant chord of *Fah, Lah, Doh*. Thus is the pupil gradually made familiar with the diatonic scale in all possible positions in which its intervals can be disposed—in fact, just as he will meet with them in his ordinary vocal routine.

But now we have to see how this Modulator scale is expressed in the notation. It is done in the very simplest way, by merely writing the initial letters of the syllable names, as here:

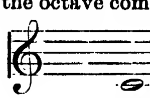
d r m f s l t

Leaving out of consideration the so-called "chromatics," to be dealt with in next lesson, nothing more is notationally required, so far as tune is concerned, but some means of indicating the higher and lower octaves of these scale notes. As the diatonic scale consists of only seven notes, it is obvious that when we have exhausted these we must begin again—must go on in a higher or in a lower direction, as the case may be. The term "octave" means eighth; and when we begin again we begin with the eighth of the original note. Thus, every *Doh*, every *Me*, every *Soh*—every note of the scale—has its octave or eighth above or below. The question, then, is, how to differentiate these octave notes from the others. This, again, is managed very simply. The upper octaves are represented by figures above the scale letters; the lower octaves by figures below, as thus:

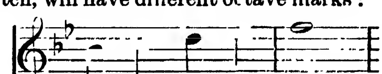
d^1 d^2

d_1 d_2

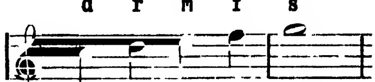
It must be understood, of course, that all the scale notes within the key are left unmarked, and that the marking begins only when the octave above or the octave below the key *Doh* is called into use. To put it in Mr. Curwen's own words, the octave commencing on middle C



is taken as a standard. The notes of that octave bear no mark above or below, and every *Doh* chosen as a key-note within that octave is unmarked also. Thus (to borrow once more from the Staff) these passages, so nearly alike in pitch, will have different octave marks:



d r m f s



d^1 r^1 m^1 f^1 s^1

because in the first case the *Doh* is within the Standard octave; in the second it is above it.

Notation of Time. The Tonic Sol-fa has this advantage over that of the Staff notation, that it indicates clearly each individual beat or pulse of the measure. In teaching time the Tonic Sol-fa instructor begins by pointing out how in speaking and in singing we accent certain words or syllables, and do not accent others. Thus, in the line "Tell me not, in mournful numbers," a strong accent comes on every alternate syllable. In "Take her up tenderly, lift her with care," again, the accent comes on every third syllable.

Now, to mark these accents, a musical composition, long or short, is cut up exactly in the same way. First it is divided by bars into measures, then in Tonic Sol-fa the measures are divided visibly into beats or pulses. The strong accent comes in every case at the beginning of the measure, and to mark it a vertical line is used exactly like the bar-line of the Staff. The sign for the weak accent is a colon (:); and when a subordinate accent—technically the medium accent—has to be shown, a short upright line is employed. Thus, "Tell me not in mournful numbers" would be set out in this way:

| : | : | : | : ||

Tell me not, in mourn-ful num - bers,

while "Take her up tenderly, lift her with care" would appear so:

| : : | : : | : : |

Take her up ten - der - ly, lift her with care.

In the first example the measure contains two pulses, and is thus said to be in two-pulse measure; while the second example, with three pulses to the measure, is similarly described as in three-pulse measure. In naming a measure the pulses are always counted from one strong accent to the next. Altogether there are six kinds of measure in common use. After three-pulse measure comes four-pulse measure, where the order of the accents is strong, weak, medium, weak, as here:

| : | : |

Then we have six-pulse measure, written thus:

| : : | : : |

Nine-pulse measure:

| : : | : : | : : |

And twelve-pulse measure:

| : : | : : | : : | : : |

These, as we have said, are all the measures in general use. We meet now and again with:

| : | : | : | : |

called eight-pulse measure, but it is only used when a four-pulse measure is to be so slow that each beat is divided into two. The six, nine, and twelve-pulse measures are made up of two, three, and four measures of three-pulse time, the medium accent being used instead of the strong. They are therefore called compound measures. It is obvious that a composition cannot always begin on the strong accent. If a composer had to "set" the words, "They grew in beauty, side by side," he would begin with a weak accent, the strong accent following on "grew."

Continued

GUMS & OTHER SUBSTANCES

Including India-rubber and Gutta-percha, Gums and Glues, Bone, Ivory, Camphor, Asbestos, Glass, and Emery

By Professor HENRY ADAMS

India-rubber. *India-rubber*, or *Caoutchouc*, consists of the dried coagulated milky juice of various trees and shrubs belonging chiefly to the natural order *Euphorbiaceæ.* The caoutchouc appears to be kept in suspension in the juice by means of ammonia; at least, in some cases the fresh milk exhales an ammoniacal odour. Probably it is on this account that the addition of liquid ammonia prevents the juice from coagulating for a considerable time, and ammonia is added, in certain districts, when the milk has to be carried some distance from the place of collection. Of all varieties the most important is Pará rubber.

Pará Rubber. *Pará rubber* is obtained from *Hevea Brasiliensis*, a large tree 60 ft. high. The caoutchouc is collected in the so-called dry season between August and February; the trees are tapped in the evening, and the juice is collected on the following morning. A deep horizontal incision is made near the base of the tree, and then from it a vertical one extending up the trunk, with others at short distances in an oblique direction. Small shallow cups, made from clay and dried in the sun, are placed below the incisions to receive the milk, each cup being attached by sticking a piece of soft clay to the tree and pressing the cup against it. Each tree yields only about 6 oz. of juice in three days.

To produce the rubber the juice is heated in the following manner. A piece of wood about 3 ft. long, with a flattened clay mould at one end of it, is dipped in the milk, or this is poured over it as evenly as possible. The milk is then carefully dried by turning the mould round and round in a white vapour obtained by heating certain oily palm-nuts, the vapour being confined within certain limits by the narrowness of the neck of the pot in which the nuts are heated. Each layer of rubber is allowed to become firm before adding another. A practised hand can make 5 or 6 lb. an hour. The cakes when completed are, in order to remove them from the mould, slit open with a sharp knife, which is kept wet, and are hung up to dry. The flat, rounded cakes of rubber made in this manner are known in the London market as "biscuits."

Ceara Rubber. *Ceara rubber* is considered next to the Pará in value. It is obtained by brushing away the loose stones and dirt from the root of the tree by means of a handful of twigs, after which the collector lays down large leaves upon which the milk may fall. He then slices off the outer layer of the bark to a height of 4 or 5 ft. The milk—which exudes in many tortuous courses, some of it ultimately falling on the ground—is allowed to remain on the tree for several days, until it becomes dry and solid, when it is pulled off in strings, which are either rolled up into balls or put into bags in loose masses, in which form it enters commerce under the name of *Ceara scrap.*

Composition of India-rubber. India-rubber is composed of carbon and hydrogen alone, but its exact chemical nature is not by any means known with certainty. When pure it is odourless and nearly white, and possesses a specific gravity of ·915. It is porous and cellular in texture, and absorbs from 10 to 25 per cent. by weight of water when soaked in it for a long period.

Industrial Preparation. In the preparation of india-rubber for industrial purposes the first matter to be attended to is the removal of the various impurities present in the crude material. This is done in the following manner. The lumps of crude caoutchouc are first softened by the prolonged action of hot water, and then cut into slices by means of a sharp knife. The softened slices are now repeatedly passed between grooved rollers, known as the washing rollers, a supply of hot or cold water being made to flow over them. Solid impurities speedily become crushed, and are carried away by the water, while the rubber takes the form of an irregular sheet perforated by numerous holes. The washed product contains in its pores a notable proportion of water, which is removed by hanging the rubber for some days in a warm room. It is now ready either for incorporation with sulphur and other solid bodies, or for agglomeration into solid masses by means of the masticating machine. Sheet rubber is largely used in the fabrication of certain classes of rubber goods, these being made by cementing the sheets together with a solution of rubber in coal-naphtha or benzol. Most articles made of cut sheet-rubber would, however, be of very limited utility were they not hardened or vulcanised.

Waterproof Cloth. The ordinary macintosh or waterproof cloth is prepared by spreading on the fabric layers of india-rubber paste or solution made with benzol or coal-naphtha. If cotton or linen is used, it is usual to incorporate sulphur with the paste, and to effect vulcanisation by steam heat; but when silk or wool is employed no sulphur is added to the paste, the dried coating of rubber being merely brought into momentary contact with the mixture of chloride of sulphur and carbon

disulphide. Double texture goods are made by uniting the rubber surfaces of two pieces of the coated material. Air goods such as cushions, beds, gas-bags, etc., are made of textile fabrics which have been coated with rubber, either by the spreading process already described, or by means of heated rollers, the vulcanisation, or "curing," as it is called, being then effected by steam heat.

Other uses to which vulcanised rubber is put are packing for stuffing boxes of steam engines, stereotypes, rubber stamps, over-shoes, fishing-boots, etc. Springs, valves, and washers are manufactured out of mixed rubber, and vulcanised either in moulds or in powdered French chalk.

Vulcanised Rubber. *Vulcanised rubber* consists of the chemical combination of sulphur with india-rubber, and not merely the admixture of the two substances. If an article of cut sheet-rubber is immersed for a few minutes in a bath of melted sulphur maintained at a temperature of 120° C., the rubber absorbs about one-tenth of its weight of that element, and, although somewhat yellowish in colour from the presence of free sulphur, it is still unvulcanised and unaltered as regards general properties. If, however, it be now subjected for an hour or so to a temperature of 140° C., true combination sets in, and vulcanised caoutchouc is the result.

Another method of vulcanising articles from cut sheet rubber consists in exposing them to the action of chloride of sulphur. Either they are placed in a leaden cupboard, into which the vapour is introduced, or they are dipped for a few seconds in a mixture of one part of chloride of sulphur and 40 parts of carbon disulphide, or purified light petroleum. Vulcanisation takes place in this instance without the action of heat, but it is usual to subject the goods for a short time to a temperature of 40° C., after their removal from the solution, in order to drive off the liquid which has been absorbed and to ensure a sufficient action of the chloride of sulphur. Treatment with a warm alkaline solution is afterwards advisable, in order to remove traces of hydrochloric acid generated during the process. Most of the rubber now manufactured is not combined with sulphur when in the form of sheets, but is mechanically incorporated with about one-tenth of its weight of that substance by means of mixing rollers, any required pigments for colouring being added. The mixed rubber thus obtained can be very easily worked into any desired form or rolled into sheets by means of the calendering machine.

Vulcanite. Vulcanite is the harder of the two forms of vulcanised india-rubber, the other form being known as soft rubber. Vulcanite differs from soft rubber in that it contains more sulphur, and is cured or vulcanised at a higher temperature. A kind of vulcanite which contains a very large proportion of vermilion is used, under the name of dental rubber, for making artificial gums.

Ebonite. *Ebonite* is a black, hardened compound of caoutchouc or gutta-percha and sulphur in different proportions, to which other ingredients may be added. It is properly black vulcanite. Ebonite takes a fine polish, and is valuable to the electrician on account of its insulating properties, and to the chemist and photographer because vessels made of it are unaffected by most chemical reagents.

Gutta-percha. The name *gutta-percha* is applied to the concreted or inspissated juice of various plants belonging to the natural order *Sapotaceæ*, growing in the Malay Peninsula. To what particular tree the name "gutta-percha" properly belongs there is no evidence to show, but it has been generally given to *Dichopsis gutta*, which usually attains a height of 60 to 80 ft., with a diameter of 2 to 4 ft. The wood is soft, fibrous, spongy, of a pale colour, and marked with black lines, these being reservoirs of gutta-percha. The collection of gutta-percha generally takes place directly after the rainy season, as in the dry season the gutta does not flow so readily. The yield of a well-grown tree of the best variety is from 2 to 3 lb. of gutta-percha, such a tree being about 30 years old, 30 to 40 ft. high, and 1½ to 3 ft. in circumference. A full-grown tree sometimes measures 100 to 140 ft. to its first branches, and may yield 50 to 60 lb. of gutta-percha, which loses in six months about 35 per cent. of its weight in drying.

The methods of extracting the gutta-percha are much the same amongst the Malays, Chinese, and Dyaks. The trees are cut down just above the buttresses, or *banees*, as they are called, and for this purpose a staging about 14 to 16 ft. high is erected. When the tree is felled, the branches are speedily lopped off, to prevent the ascent of the gutta to the leaves. Narrow strips of bark, about 1 in. broad and 6 in. apart, are then removed; but not all round the tree, as its under part, in its fall, becomes buried in the soft earth, much sap being thus lost. Some natives beat the bark with mallets to accelerate the flow of milk or gutta, which flows slowly and rapidly concretes. The gutta is received into hollow bamboos, doubled-up leaves, pieces of bark, cocoanut-shells, or in holes scraped in the ground. If the quantity obtained is small, it is prepared on the spot by rubbing it together in the hands into a block, in one end of which a hole is made to carry it by; in this state, it is known in the market as *raw gutta* or *gutta muntah*.

Preparation. Gutta-percha, as received in England, is in irregular clumps or blocks, and is frequently adulterated with massive stones, sawdust, bark, sago-flour, etc., and the first step in its manufacture is to cleanse it thoroughly. The blocks are first sliced by means of a powerful circular wheel, driven by machinery, and having fixed to it two or three strong chisel-like knives. These slices are placed in wooden troughs, filled with water and heated by steam. As soon as the gutta-percha becomes soft, it is taken out in baskets and placed in a toothed iron cylinder, called a

"devilling" machine, which tears it into fragments. These fall into a trough of water, and the impurities sink to the bottom, leaving the purified gutta floating in the form of a spongy mass. This mass is then taken out, thoroughly washed in cold water, and dried in baskets. It is then placed in jacketed iron chests, heated by steam, and left till it becomes soft, when it is at once removed and placed in a machine called a *masticator*, which kneads or masticates it, the result being a homogeneous dough-like, reddish-brown mass. While still hot this mass is placed between two steel cylinders and thoroughly rolled. By means of an endless band of felt the gutta is returned again to the cylinders, the distance between which is gradually diminished, so as to compress and completely drive out any contained air from the gutta-percha.

Uses of Gutta-percha. In telegraphy gutta-percha is of the very highest importance, being a cheap, lasting, and powerful insulator, easily applied to telegraphic wires. The value of gutta-percha piping is very great; it does not contaminate water as lead piping does; it withstands insects, damp, etc., and is easily manipulated, being shortened, lengthened, or repaired with little trouble or expense; and its acoustic properties have led to its employment in the manufacture of aural, stethoscopical, and other instruments. Gutta-percha speaking-tubes are now widely used. The substance is also largely employed for funnels, syphons, and other chemical apparatus, from the fact that few acids and alkalies affect it. It is also used for golf balls, and may be moulded into any shape by simply softening it in hot water and pressing it into the mould.

Gum. Gum exists in the juices of almost all plants, but is produced in its purest form by various species of *acacia*. The name is applied to those exudations from plants, stems, branches, or fruits which are entirely soluble or soften in water, and form with it a thick glutinous liquid. In structure, gum is quite amorphous, being neither organised, like starch, nor crystallised, like sugar. According to Trecul, the acacias yield their gums more abundantly when sickly and in an abnormal state, caused by a fulness of sap in the young tissues, whereby the new cells are softened and finally disorganised; the cavities thus formed fill with liquid, which exudes, dries, and constitutes the gum.

Gum-arabic. Gum-arabic may be taken as the type of the gums entirely soluble in water. The principal kinds are distinguished as Turkey picked gum, Gedda, Amrad, Gheziri, Senegal, Talca, Australian, Barbary, Cape, and East Indian (from Bombay and Aden). It occurs in pieces of varying size, and some kinds are full of minute cracks. The specific gravity of Turkey picked gum (the purest variety) is 1·487, or when dried 1·525. The finer varieties are used as an emollient and demulcent in medicine, and in the manufacture of confectionery. The commoner qualities are used as an adhesive paste, for giving lustre to crêpe, silk, etc. For labels it is usual to mix sugar or glycerine with it to prevent it from cracking.

Gum-tragacanth. Gum-tragacanth called also *gum dragon*, exudes from the stem, the lower part especially, of the various species of *astragalus*, and is collected in Asia Minor and shipped from Smyrna. It has a dull white colour, and occurs in horny, flexible, and tough, thin, twisted flakes. It is used in calico-printing as a thickener of colours and mordants; in medicine as a demulcent and vehicle for insoluble powders, and as an incipient in pills.

Gum-benjamin. *Gum-benjamin*, *benjamin*, or *benzoin*, together with other resins, such as copal, mastic, shellac, kawrie, or cowdie, or Australian copal, etc., are often improperly called gums.

Mastic. *Mastic* is a resinous exudation obtained from the *Pistacia Lentiscus*, or mastic plant, an evergreen shrub found in the Mediterranean coast region from Syria to Spain, but growing also in Portugal, Morocco, and the Canaries. The resin is not contained in the wood, but in the bark, and to obtain it numerous vertical incisions are made in the stem and chief branches. Besides that obtained from the incisions, mastic of very fine quality spontaneously exudes from the small branches. Mastic occurs in English commerce in the form of roundish tears about the size of peas, some, however, being oblong or pear-shaped. They are transparent, with a glassy fracture, of a pale yellow or greenish tinge, which darkens slowly by age. Its solution in turpentine constitutes a varnish much used in oil-painting.

Gelatine. The gelatine derived from bones enters very largely into human food, in the stock for soups, etc., and as prepared gelatine, calves-foot jelly, and isinglass. It is employed as a sizing agent in paper-making, and by painters it is also used for sizing or priming. It is further used in the preparation of elastic moulds of undercut work, and in the manufacture of inking-rollers for printing.

Glue. Glue is a form of gelatine, which, on account of its impure condition, is employed only as an adhesive medium for wood, leather, paper, and like substances. In the preparation of ordinary glue the materials used are the parings and cuttings of hides from tanyards, the ears of oxen and sheep, the skins of rabbits, hares, cats, dogs, and other animals, the parings of *tawed* leather, and many other scraps of animal matter. Taking tanyard refuse to be the principal material, it is first steeped for some weeks in a pit with lime-water, and afterwards carefully dried and stored. The object of the lime steeping is to remove any blood and flesh which may be attached to the skin, and to form a lime soap with the fatty matter it contains. When thus prepared, the glue pieces, or *scrows*, as they are termed, are thoroughly washed before boiling. They are then placed in hemp nets and introduced into an open boiler, which has a false bottom, and a tap by which liquid may be run off. As the boiling proceeds, test quantities of liquid are from time to time examined, and when a sample is found on cooling to form a stiff

jelly, it is ready to draw off. From the boiler the solution is run to a tank or *setting back*, in which a temperature is maintained sufficient to keep it fluid, and in this way any impurity is permitted to subside. The solution is then run into wooden troughs or coolers, in which it sets to a firm jelly. When set, a little water is run over the surface, and with knives of suitable form it is detached from the troughs, cut into slices about an inch thick, and these are placed on nets stretched between upright wooden frames for drying, an operation which requires special care.

Isinglass. *Isinglass*, or *fish-glue*, in its raw state is the swimming-bladder, or sound, of various species of fish. Russian isinglass, which is the finest made, is obtained from several species of sturgeon found in the Volga, Caspian and Black Seas, and in the Arctic Ocean. It is prepared by cutting open the sounds, steeping them in water till the outer membrane separates from the inner, then washing the latter and exposing it to dry in the air. The principal uses to which isinglass is applied are for jellies and confections, and as a clarifying or filtering medium for wine, beer, and other liquids. When dissolved in strong acetic acid it forms a powerful cement, much used for repairing glass, pottery, and similar small objects.

Marine Glue. Various adhesive but non-gelatinous substances are, on account of their properties, known commercially as glue, and are used as substitutes for ordinary glue. Thus marine glue, employed in shipbuilding and for other purposes, is a compound of india-rubber and shellac dissolved in coal-tar naphtha.

Bone. Bones of cattle and other animals are extensively used in the arts in forming knife-handles, buttons, combs, etc., in making size, gelatine, lampblack, and animal charcoal, and for various other purposes. They are also extensively used as a manure for dry soils, with the very best effect, being ground to dust, bruised, or broken into small fragments in mills, or dissolved in sulphuric acid.

Horn. The weapons which project from the heads of various species of animals, constituting what are known as horns, embrace substances which are, in their anatomical structure and chemical composition, quite distinct from each other, and although in commerce also they are known indiscriminately as horn, their uses are altogether dissimilar. Their differences are thus indicated by Professor Owen: "The horns of deer consist of bone, and are processes of the frontal bone; those of the giraffe are independent bones covered by hairy skin; those of oxen, sheep, and antelopes are projections of the frontal bone, covered with a sheath of true horny material. Only the horns of the rhinoceros are composed wholly of horny matter, and this is disposed in longitudinal fibres, so that the horns seem rather to consist of coarse bristles compactly matted together in the form of a more or less elongated sub-compressed cone." True horny matter is really a modified form of epidermic tissue, and consists of an albuminoid principle termed *keratin*. It forms not only the horns of the ox tribe, but also the hoofs, claws, or nails of animals generally, the shell of the tortoise, porcupine quills, and birds' feathers, etc.

The principal application of horns is for the manufacture of combs; and other uses to which the substance is put are pressing of buttons, handles for walking-sticks, umbrellas and knives, manufacture of drinking-cups, spoons, snuff-boxes, etc. The parings and refuse of horn are valuable for the manufacture of prussiate of potash and as manure, and the ash of the cores of horn makes excellent cupels for the assay of precious metals. Deer-horn is used almost exclusively for handles by cutlers and walking-stick and umbrella makers.

Ivory. Ivory is essentially equivalent to dentine, that hard substance of which most teeth are principally composed. By usage, however, its application has become almost restricted to the dentine of those teeth which are large enough to be available for industrial purposes—*viz.*, the tusks of the elephant, hippopotamus, walrus, narwhal, and sperm whales.

The best ivory is the African, and the first quality of that comes from near the Equator. The tusks are sold by weight, and stones and iron are sometimes thrust down into the hollow pulp cavity to increase the weight, so that dealers generally feel the hollow with an iron rod to detect foreign matter.

The tusks of the extinct mammoth from Northern Siberia furnish almost the whole of the ivory used by Russian ivory workers. They come principally from the neighbourhood of the Lena and other large rivers discharging themselves into the Arctic Ocean, and are abundantly found in the Liakhoff Islands. Mammoth tusks are slender, much more curved, and in proportion to the size of the animal much larger than those of our elephants. In England this ivory is not very highly esteemed, being considered too dry and brittle for elaborate work, and very liable to turn yellow.

The great canine teeth of the hippopotamus furnish an ivory which is harder and whiter than that of the elephant and less prone to turn yellow. No large piece can be obtained from a hippopotamus tusk, and the incisors and upper canine teeth yield even smaller pieces than the lower canines.

The tusks of the walrus have long been used as a source of ivory among the northern nations. The upper canines are oval in section, solid, and their axis is made up of secondary dentine, which makes up a considerable part of the whole tooth, the quantity far exceeding that in the hippopotamus. The spirally-twisted tusk of the narwhal, the teeth of sperm whales, the ear bones of whales, and the molar teeth of elephants, are also all made use of as sources of ivory, though they are far less valuable than the larger tusks.

Uses of Ivory. In former times ivory was frequently used for the manufacture of artificial teeth, but it has been superseded by more durable and more manageable materials. The principal demand for ivory arises in

connection with the cutlery trade, very large quantities being used for the handles of pocket and table knives. It is also extensively used for the handles of walking-sticks and umbrellas, combs, paper-knives, ladies' fans, and for measuring-rules, and mathematical scales. It is in considerable demand for the manufacture of chess and draughts men, for statuettes, caskets, and many minor objects of furniture and ornament, and for inlaying. All ivory dust and chips are utilised by being converted into gelatine—which they may be made to yield by prolonged boiling—or by being calcined into ivory black.

Vegetable Ivory. The plant yielding the vegetable ivory of commerce is known to botanists as *Phytelephas macrocarpa*, and is a native of South America. The fruit consists of a conglomerated head, composed of six or seven drupes, each containing from six to nine seeds, and the whole being enclosed in a walled woody covering, forming altogether a globular head as large as that of a man. A single plant sometimes bears at the same time from six to eight of these large heads of fruit, each weighing from 20 to 25 lb. In its very young state the seed contains a clear, insipid fluid. As it gets older the fluid becomes milky and sweet to the taste, and gradually continues to change, both in taste and consistence, until it becomes so hard as to make it valuable as a substitute for animal ivory. The seeds, or nuts, as they are generally called, when fully ripe and hard, are used by the American Indians for making small ornamental articles and toys. They are imported into Britain, frequently under the name of Corozo nuts, and are used chiefly for small articles of turnery.

Xylonite. *Xylonite, Zylonite,* or *Celluloid*, is a substance made of guncotton, camphor, and ivory dust, imitating ivory, or, when coloured, tortoise-shell, coral, amber, etc. Celluloid has recently been introduced for stereotypes instead of metal, and it is found that many thousands more impressions can be printed from them than from stereotypes without showing perceptible signs of wear. It is used in the manufacture of billiard balls, combs, small mirror backs, pocket-book covers, and other small objects. It is also used in the manufacture of collars and cuffs, but its fiercely combustible character renders it somewhat dangerous.

Camphor. *Camphor* is a translucent substance, of cooling taste and penetrating odour, distilled from the wood of the camphor-tree (*Cinnamomum camphora*), which flourishes in the Island of Formosa, and also in Japan and parts of China. It is produced from the branches, trunk, and roots of the tree by cutting them into chips, which are placed in closed vessels and exposed to the vapour of boiling water, the steam volatilises the camphor, which comes to the top of the vessel. Camphor is largely used in the production of celluloid goods, and in the manufacture of smokeless powder and cordite. It is also employed in the making of medicaments, and in keeping moths away from furs and woollen goods.

Mica. *Mica* is one of a group of minerals, all of which are characterised by their perfect basal cleavage, in consequence of which they can be separated easily into extremely thin, tough, and usually elastic laminæ. The micas are silicates of aluminium with other bases, as iron, calcium, magnesium, potassium, sodium, and in some kinds fluorine is present in small quantities. The micas, of which there are several varieties, enter into the composition of many rocks, including the crystalline rocks, both metamorphic and volcanic (as granite, gneiss, mica-schist, etc.), and sedimentary rocks (as shales and sandstones), sometimes giving them a laminated structure. Mica (*muscovite*) is often used in thin transparent plates for spectacles to protect the eye, in reflectors, instead of glass, in places exposed to heat, for unbreakable lamp chimneys, deflectors over gas-jets, and, in Russia, even for windows. When ground to powder, mica is combined with varnish to make a glittering coating for wall-papers, and is used also in preparing a covering for roofs, and as a packing and lubricant for machinery. *Talc* is a similar material and is a magnesian silicate.

Asbestos. *Asbestos* is a variety of the hornblende family of minerals. It consists of fine crystalline elastic fibres, with a silky lustre, varying in colour from white to grey and green, and derives its name from being specially indestructible by fire. A single fibre of it fuses to a white enamel, but in the mass it is capable of resisting ordinary flame. There are several varieties of asbestos: (1) *Amianthus* is the rarest kind, its fibres being white, flexible, long, and regularly laid. It is found in the centre of the older crystalline rocks in the Pyrenees, North America, Sweden, New South Wales, etc., but the most beautiful specimens come from Tarantaise, in Savoy, and from Corsica, where it is somewhat abundant. (2) *Common asbestos* is not so light, either in colour or weight, as amianthus, and is more inflexible, splintery, and irregular in structure. It is found in serpentine rocks in Anglesea, in Cornwall, and in several parts of Scotland, as Glenelg in Inverness. (3) *Mountain leather and mountain cork* are other varieties where the fibres are less flexible and regular than either of the above, while their colour is brown or dirty white. Mountain leather is in thin flexible sheets, and mountain cork is so named from being not unlike common cork, and so light as to float on water. It is found in Lanarkshire. (4) *Mountain wool* is a soft, tough, opaque brownish-coloured variety of asbestos, much heavier than the last, and melting to a black slag before the blow-pipe. It is found in Tyrol, in Dauphiny, and in Scotland at Glen Tilt, Portsoy, and Kildrummy. Paper has been manufactured from asbestos, and would prove invaluable, in case of fire, for charters and other important documents were it not that the paper is rather tender for use, and that the writing disappears after a red heat. More success has attended its employment for fireproof roofing and flooring, for non-conducting envelopes of steam-pipes, and for the packing of fireproof

safes; it is also prepared as a cement for protecting heated surfaces, roofs and floors, and for various fireproofing purposes.

Uralite. The main ingredient of this substance is asbestos, obtained from Canada, the United States, and Russia. This is cleansed, and afterwards mixed, with water and chalk as a binding agent, into a pulp similar to that of paper pulp. The pulp is rolled into sheets, and, for the purpose of securing stability, a small quantity of silicate of soda is added to it. The sheets thus formed are cut into the sizes required, pressed, and dried, leaving boards of fibrous asbestos. These boards are steeped in a solution of silicate of soda, the water is driven off by drying, and they are then dipped in a solution of bicarbonate of soda and again dried. The technical application consists of the impregnation of the asbestos board by silicate of soda, and its subsequent decomposition by bicarbonate of soda. This is accomplished by regulating the strength of the two solutions so as to ensure the complete impregnation of the whole of the board by the two chemicals, which are of mineral character. In this way the time of deposition is determined, and, after a sufficiency of the colloid silica is deposited over the fibres of the asbestos, it is gradually dried until the 75 per cent. of water, natural to freshly formed colloid silica, is driven off, leaving a hard, dense substance which attaches itself as a cement to the asbestos, and thus forms a homogeneous mass incapable of lamination, with no planes of cleavage, and fire-resisting to a high degree. When made in sheets it is used for roof covering, ceilings, floors, and partitions, and can be veneered, varnished, and worked with carpenters' tools like ordinary timber. It will stand 2,000° F. without destruction, and is coming largely into use.

Slag-wool. *Slag-wool* or *silicate cotton* is made from the slag of blast furnaces, by allowing a jet of steam to blow through a stream of molten slag while falling, converting it into a glassy substance with the texture of cotton-wool. Owing to its fire-resisting properties, it is used as a substitute for asbestos in the manufacture of several fire-resisting plasters. It is extensively used as a sound-proof packing, which is not subject to decay, and does not harbour vermin. It is a favourite substance for use as a non-conductor in refrigerating chambers, as it is impervious to damp, and unaffected by temperature.

Fossil Meal. *Fossil meal*, or fossil flour, is a variety of infusorial earth found in abundance in Tuscany and elsewhere beneath peat beds. It is a white flour-like powder used in the manufacture of *floating bricks*, and for non-conducting boiler coverings.

Glass. *Glass*, in its ordinary signification, is a brittle, transparent compound produced by the fusion, at a very high temperature, of silica (*silicic acid* or *oxide of silicon*) with one or more basic substances, one of which, in all cases, must be an alkaline metal. The substances which form the essential basis of all varieties of common glass are (1) silica as the acid element; (2) soda or potash as the alkaline base, and (3) lime and oxide of lead as the alkaline earths. To the alkaline earths commercially employed there ought also to be added baryta and alumina, the former being used in the place of lead, and the latter a common ingredient in certain kinds of glass. The properties on which the great value and utility of glass principally depend are (1) its well-known prevailing transparency, combined with a brilliant lustre and great hardness; (2) its fusibility at a high temperature; and (3) its softness and viscosity at a red heat, whereby it can be worked with facility into any desired shape. Of great value also is its resistance to the influence of common solvents. Properly made, glass is not sensibly acted upon by any of the acids except hydrofluoric acid, which attacks it powerfully, combining with and removing its silica. Of the many varieties of glass manufactured may be mentioned: crown, sheet, plate, flint or crystal, pressed, baryta, bottle, massive, spun, etc., but of these, only the first three are in common use in connection with the building trade.

Emery. *Emery* is an impure variety of the mineral corundum, bluish-grey to brownish, granular and rough in fracture, with a specific gravity varying between 3·7 and 4·3. Much of the emery of commerce is artificially coloured to a rich reddish brown. It occurs in amorphous masses in schists, gneiss, granular limestone, and other crystalline rocks, and in rolled and detached pieces and in granules in soils. The principal European source of emery is the island of Naxos, but it occurs also near Smyrna, and in Sweden, Saxony, Spain, and other localities. When broken by hammer, or crushed by stamps, it is used as a polishing material for plate glass, crystal, lapidaries' work, and metals, and in cutting granite and marble. Emery-powder is mixed with other substances and formed into grinding wheels, hones, and similar instruments. Emery, more especially that used for emery-paper and emery-cloth, is commonly adulterated with garnet, zircon, iron-slag, and other substances harder than quartz sand.

Carborundum. *Carborundum*, which on account of its great hardness has assumed an important place among abrasives used for polishing, is a silicate of carbon, formed by the action of carbon on sand (*silica*) at high temperatures in the electric furnace. When taken from the furnace it is crystalline, green, blue, or brownish in colour, sometimes opaque, but often translucent, resisting the action of even the strongest acids, and the action of air or sulphur at high temperatures. The crude product can, therefore, be treated with hot sulphuric acid to purify it. In hardness it nearly equals the diamond, and it is used for tool-grinding in the form of vitrified wheels. Carborundum-paper—made like emery-paper—is now largely used in place of garnet-paper in American shoe factories.

Continued

LADY'S-MAID, FOOTMAN, & COACHMAN

Duties of the Lady's-maid. Hairdressing. Needlework. The Footman's Duties. General Manservant. Page and Houseboy

By A. EUNICE T. BIGGS

THE LADY'S-MAID

The lady's-maid ranks with the valet, and she takes her meals with him, together with the butler, in the housekeeper's room. Her duties bring her into personal contact with her mistress, and it is important that she should possess certain mental and moral qualities to fit her for the work. She should have both tact and patience, and be able to exercise forbearance and self-control should her mistress be unreasonable and capricious. She will do well to maintain a respectful manner, and to be very considerate with her mistress. She should never repeat to the other servants anything that may come to her ears, and she should take care that information of a private character, which may accidentally become known to her, is not repeated.

Duties of the Lady's-maid. The lady's-maid's first duty will be to make preparations for her mistress's toilet. She should put everything in order in the dressing-room, lighting the fire if the weather is cold. The bath should be prepared, with plenty of hot and cold water in readiness, and an early cup of tea made for her mistress, if she wishes for it. She should then, at the appointed time, call her mistress, give her her tea, pull up the blinds, and close the windows. She should put out all clean linen to be aired, and put away every garment that has been left out from the evening before. The lady's-maid then goes downstairs to her own breakfast, and her mistress will ring when she is ready for her.

Hairdressing. It is of the utmost importance that the lady's-maid should be skilful in dressing hair. If she can obtain some lessons from a good hairdresser she will find them invaluable. Many ladies who find their maids satisfactory in all other respects will occasionally send them to have a few lessons, in order to acquire the latest styles.

Having helped her mistress to dress the [illegible] the [illegible] all [illegible] the bedroom and dressing-room. The visits of the housemaid to these apartments will, in this case, be confined to the occasions on which the rooms are thoroughly turned out.

The Daily Routine. As soon as her mistress has gone down to breakfast, the lady's-maid should throw back the bed and open the bedroom windows, and in about half an hour the room will be thoroughly ventilated. She can then return to the room and begin its rearrangement. The whole process of cleaning and dusting must be carried out with great care. Every particle of dust must be removed, the ornaments dusted, glass and silver ornaments polished, and the dressing-mirror and handglass cleaned.

The silver will need particular attention, especially in a town where the fog and smoke will quickly blacken it. The hairbrushes should also be cleaned. All hair is first drawn out of the bristles with the comb. Some very hot water is placed in a basin, and some soda added. The brush is then cleaned by dipping the bristles in and out of the hot solution, care being taken to keep the handle and back of the brush quite dry. When the bristles are clean, they should be rinsed in cold water, and then shaken, to dry them as much as possible. The final drying may be effected by the sun, which will whiten the bristles, or by the fire, which will make them rather stiffer. In any case, the bristles must not be rubbed with a cloth, as such treatment makes them soft. A little ammonia may be added to the washing water, but no soap should be used. The comb should but seldom be washed. It can be effectively cleaned with a small brush, or by rubbing on a clean cloth.

Duties in the Bedroom. The housemaid will probably help the lady's-maid with the process of bedmaking and the other details of the bedroom arrangement. She should study her mistress's personal likes in all these details, and do her best to please her in every way. In putting away her mistress's dresses, the maid should see that they are well brushed, and that any little attention in the way of mending or renovating is not neglected. She should then examine the dresses that her mistress will wear later in the day, and put them out in readiness for use. She should also notice carefully that nothing is wanting in the rooms under her charge. Should anything be missing, she should tell her mistress before she goes out, so that she may give orders for its purchase. She should see that her mistress's apartments [illegible] dresses, after a short [illegible] replaced in the wardrobe.

The Maid's Wardrobe Duty. The greater part of the day will be devoted to needlework—making, mending, renovating, altering; which duties will keep her busy day after day. In a thousand little ways the lady's-maid who is skilful with her needle can make herself invaluable. In the matter of mending, she should take charge of everything except stockings and woollen underwear before it goes to the laundry. A small rent will become larger if not mended before the garment is washed.

When the linen has been carefully overhauled, the maid should make a list of all that is sent to the laundry, and check the articles when they are returned to see that none are missing. In spite of the mending previous to the sending to the laundry, many little repairs may be necessary after their return. Buttons will doubtless be missing, tapes torn off or allowed to "run out"; these defects must always be remedied. Then, if the mistress prefers narrow, coloured ribbons to tapes in her underwear, the lady's-maid should remove these, and also fragile lace, before sending the article to the laundry; wash them carefully herself, and replace them afterwards.

Dresses of soft, crushable material, such as washing silk or muslin, will need attention every time after wear. They will become crushed, and need smoothing with an iron, although they are not dirty enough to send to the laundry.

Travelling. Many ladies take their maids with them when paying visits. In any case, it is the maid's duty to pack the travelling trunks. The maid should lay out all that is necessary for her mistress's visit, and ascertain exactly what her wishes are with regard to which dresses shall be taken, etc. The dress-trunk should then be carefully dusted and packed.

Heavy articles, boots and shoes, should be placed near the bottom of the box, and the linen spread flat to form the next layer. Above this should come skirts, etc., and lastly, bodices, blouses, and dainty articles that are likely to crush. Between the various layers plenty of tissue paper should be placed, and care should be taken to protect by an intermediate layer all light coloured articles from those of darker tint. Special covers of linen or white calico may be used for very delicate articles, and the greatest care must be taken that bottles containing perfume, toilet lotions, etc., are securely packed in corners where they are not likely to upset.

During the journey the maid will probably travel in an adjoining compartment, and should be in readiness to wait on her mistress should there be any changes or long waits at intermediate stations. Arrived at their destination, the lady's-maid will be shown her mistress's room, where she should unpack, and try in every way to make all as comfortable as possible. During the visit her duties will be much the same as those which devolve upon her at home. She will be responsible for personal attendance on her mistress, and should always be in readiness to wait on her when summoned by the bed-bell. She will take her meals in the housekeeper's room, where the need for reticence on her mistress's concerns is, of course, even greater than at home.

THE FOOTMAN

The duties of the footman vary considerably, according to whether he works single-handed or whether there are other footmen working under him. Where others are kept the head footman works in conjunction with the butler. He helps in, or supervises, the laying of the table for meals, and in the serving of afternoon tea and coffee after dinner. During meals he waits at table, under the butler, taking precedence of the other footmen. In the afternoon he should be in readiness to answer the front-door bell. If a valet is not kept, he will doubtless be required to give a certain amount of personal attendance on his master, looking after the brushing and putting away of his clothes, and preparing his room for the morning's toilet.

If there are visitors in the house who have not brought their own valets, he will probably be called upon to give them similar personal attendance. He will have no responsibility with regard to the washing of glass and the polishing of plate beyond that of seeing that the under-footmen carry out their duties in this direction efficiently.

Duties of the Second and Third Footmen. The second footman has more onerous duties than those of the head footman, whom, in every way possible, he is called upon to assist. He may occasionally wait in the hall if many visitors are expected. His table duties include assistance in waiting, and in the washing of the glass and silver used in the dining-room. In the afternoon he may be called upon to go out with the carriage if the ladies of the house wish to pay calls. In this case he should see that they are seated comfortably, and the rugs and wraps adjusted satisfactorily. He should place the umbrellas or sunshades in the carriage, and take from his mistress her order to the coachman as to the direction of the drive. He will then close the carriage door, and mount to his seat beside the coachman. When the house at which the mistress intends to call is reached he should descend from his seat, ring, and find out if the ladies are at home, telling his mistress and awaiting her orders.

The third footman is responsible for the heavier dirty work, such as cleaning the knives and boots, filling the coalscuttles, etc.—in fact, carrying out the duties of a houseboy, if one is not kept.

GENERAL MANSERVANT

The single manservant does not wear livery, but his duties combine the most important items of the work of a butler, footman, and valet. He should rise early, and get such work as boot and knife cleaning finished before breakfast. He should see that his master's clothes are brushed, and that hot water is in readiness in the dressing-room. He should then take his own breakfast, and afterwards set that of the household. After he has put the hot dishes on the table, he will probably not be required to wait at table, but may withdraw and begin to busy himself with the morning's task. This may be plate-cleaning, etc.; and he will also have to answer the front door.

He will then set the luncheon, and attend at that meal until he is dismissed from the room, when he may retire and take his own dinner. After luncheon he will clear the tables, clean and wash the plate and glass used, and

in the afternoon he will generally answer the front-door bell, or go out with the carriage. In the evening his duties will include the laying of the dinner-table. He may be assisted by the parlourmaid, and also in the waiting at table during this meal. After dinner he will clear away, either unaided or assisted as before, and a little later bring in the coffee.

Characteristics of a Good Footman. Certain physical characteristics are generally required in a good footman, such as fair height and good carriage. He should be invariably attentive and polite. He may often be sent on messages, or with notes, and should restrain his curiosity as to their purport, and take only such time as is necessary for their delivery. In bringing a note or a card to his mistress he should offer it on a salver. In answering the door he should announce visitors distinctly by name, being careful to listen attentively when the visitor answers his query, "What name, please?" Then in opening the front door for departing guests he should close the carriage door, unless they are accompanied by a footman. The front door should not be closed until the visitors are a short distance from the house.

Coachman-gardener. The single manservant sometimes confines his attention to outdoor work. The garden may fall to his share, and the rest of his time be devoted to boots, knives, window-cleaning, and the carrying of coal and the trimming of lamps. In such households the outdoor manservant may also be required to act occasionally as coachman, should a carriage of any description be kept. In this case, his time will be fully occupied with his outdoor duties and those enumerated above, which include the rougher housework.

He will not be required to do any other indoor work, or to wear livery, except perhaps when out driving. The outdoor manservant will probably be required to arrive about seven in the morning. Before breakfast he will probably clean the boots and bring in the coal. Then he will go home to his breakfast, unless by arrangement he takes it with the other servants of the household. He will busy himself in the garden until after dinner, when he will probably be required to drive his mistress. On his return he will have the carriage to clean and the horse to look after, and about 6 p.m. he will be free to leave. He will doubtless be required to call at the house for any particular orders, or to take letters to the post.

PAGE AND HOUSEBOY

The page wears a livery, and his duties vary considerably in every household. In some, where he is kept as a concession to appearance, he will be expected to be neat, and ready always to answer the front door. He may also have to wait at table and carry messages. In the case of professional men, it is almost a necessity for a page to be kept whose almost exclusive duty it is to answer the front-door bell. In other cases a boy is kept who does not wear livery, nor appear beyond the kitchen precincts. Such a boy is a useful adjunct in a house where no other manservant, either indoor or outdoor, is kept.

The chief work of the houseboy is to perform tasks which are too heavy for the maidservants. For example, he will bring in coal, clean the knives and boots, and in general make himself useful to the cook and housemaid. Both page and houseboy may, by making good use of their opportunities, fit themselves to perform more important duties as they grow older. The most capable butler is generally the result of many years' training in a gentleman's house. By beginning when young at the bottom of the scale he may gradually work his way upwards, learning in turn the duties of each indoor manservant from page to butler. In this way, by the time he is old enough to undertake the onerous and responsible duties of butler, he has gained a thorough knowledge of the duties of each servant he will have to supervise. His knowledge of their duties will be thorough, and will enable him to so direct the work of those under his control that he will ensure the most efficient service for his master.

THE COACHMAN

The coachman is the head of the stables, and should have a wide experience in dealing with horses. He should be skilful in driving, and able to decide wisely in matters concerning the exercise and feeding of the horses entrusted to him. Experience should have taught him how to deal with the minor ills which affect horses, and he should be able to discriminate between unimportant trifles and the symptoms of more serious disease. The coachman's chief duty is to drive, and to drive well. Incidentally, he will have other duties connected with the care of the horses, the stable arrangements, and the cleaning of the carriage, but his chief work is the management of the horses. He will probably be required to assist in their choice, and so should be a judge of horseflesh. In selecting a pair he should endeavour, if his master allows him to assist in the choice, to select two that are well-matched, not only as regards colour and height, but also in habits and pace. Should they differ widely, he must use his discretion in making them work together as harmoniously as possible.

He should see, before driving up to the front door to fetch his mistress, that everything connected with both carriage and horses is well-arranged and in order. He is not expected to descend from the box, even should no other manservant accompany the carriage, for the ladies can open the door from the inside themselves. During the drive the coachman should confine his attention to the horses, and avoid any distraction which might lead to an accident. He should avoid letting his horses get into lazy habits, but at the same time he must not overdrive them. [See DRIVING.]

Continued

MINOR FIBRES & STRUCTURE OF FIBRES

Conclusion of the Survey of the Raw Materials of the Textile Trades.
The Microscopic Structure of Fibres in Relation to Commercial Value

Continued from page 731

By W. S. MURPHY

Rivals of Cotton. Sometimes the merits of neglected fibres are re-discovered and brought before the world by ardent enthusiasts. *Madar, Mudar*, or *Yercum*, is one of those fibre plants about which extravagant hopes have been raised, with disappointment and consequent reaction. About the middle of the nineteenth-century textile manufacturers were informed that this tree was the universal provider of textile fibres. It was, in itself, a producer of wool, cotton, and flax. These extravagances had a basis in fact. From the large pods of the fruit a fine silky cotton floss is derived, and the inner bark of the tree contains a fibre admitted to be one of the finest of all vegetable fibres. When it is further understood that the plant will grow abundantly, without care or culture, in any tropical climate, on soils otherwise barren, the hopes excited by its discovery may be appreciated. The floss could be spun, but it lacked the mobility and tensile strength of the fibres already in use, and no further trouble was taken with it. The bast, or stem fibre, too, offered difficulties when subjected to commercial tests. Bark-stripping by hand was costly, and no machine had been invented to do the work. Other objections, more or less unreal, were raised, and the discouraged friends of the fibre deserted the cause. We think renewed attention ought to be given to this plant. The French now utilise it in the manufacture of fans.

Another plant of great possibilities is the *Paper Mulberry*, found growing wild, and extensively cultivated throughout Eastern Asia and Polynesia. It is a small tree, and the fibre is found in the bark. The Japanese already use the bark for making fine papers of wonderful strength; they also prepare the fibre for spinning and weave it with silk, while the yarn by itself is made into a strong cloth resembling corduroy. Expert opinion favours the paper mulberry above ramie, though the fibre is chiefly known in this country as a paper-making material.

Rivals of Ramie. Among these the *Ban*, or *Bon Rhea*, of Assam may be mentioned. It is a nettle, closely related to its better-known rival, and produces a fibre of great strength and fineness, which possesses the power of resisting moisture. The Assamese use it for fishing-lines and nets. We understand that it has been favourably reported on to the Indian Government, and successful cultivation in Assam would greatly enhance the reputation of the fibre; but the labour difficulty in that region presents a serious obstacle to immediate experiment.

19. KAPOK
Which yields a valuable stuffing material

A Fine Floss. *Kapok* [19] is a silky white floss developed in the fruit pods of the white silk cotton - tree, which grows largely in India, Ceylon, Africa, and the West Indies. The pod varies from 3 to 4 in. in length, and measures 2½ in. in diameter at the centre, tapering to blunt points at both ends. Of a yellowish buff colour when ripe, it splits open lengthwise, and a heavy tress of fine floss springs out. Originally started from Java by Dutch merchants, the trade in this material has attained considerable dimensions, and it deserves close attention. As a vegetable stuffing material, kapok has no superior. As "vegetable down," it commands a good price on the London market.

The Basis of a Colonial Industry. *New Zealand Flax* [20] has been misnamed; it is not a flax, and belongs to the lily family. When properly dressed, the fibre can be used for most of the purposes for which flax is used; but

careless gathering and dressing have greatly reduced the market reputation of the fibre. Perhaps the fact most important in connection with this fibre is the establishment of an important industry in New Zealand on the basis of "Phormium tenax," as the plant is named. Alone in Australasia, New Zealand has flax manufactures, the industry employing, in 1903, 2,637 male workers.

Allies of Flax. *Ban Ochra*, or *Toja*, grows in the tropics of both hemispheres. The fibre, which can be easily treated, is said to be a good substitute for flax.

Red Sorrel grows in the West Indies, and is widely cultivated throughout India and Ceylon for the sake of its fleshy calyx, from which an excellent jelly is made. The fibre from the stem is strong and of silky quality, largely used by the natives for cordage.

20. NEW ZEALAND FLAX

The *Pineapple* is well known as a fruit, but it may be made to yield also a very good fibre, capable of being woven into fine fabrics. A native of tropical America, the pineapple has been successfully cultivated in South Africa, and all over Australia, the crop being specially cultivated in Queensland. The fibre is derived from the leaves of the plant, and as growers, for the most part, cultivate for the fruit, the best quality of fibre is derived from the wild plants. If the fibre were to come greatly into favour, as it might very well do, growers would pay more attention to the development of the leaf. Fibre has been taken from the pineapple leaf 6 ft. long.

Hempen Fibres. The *Abrome* abounds in the hotter parts of India, and is cultivated by the natives for its fibre, used for cordage. This little bush should be better known than it is, because its fibre is fine, white, lustrous, and strong, and might be used as a substitute for silk. So quickly does the plant grow that three crops can be reaped in one year. It responds to cultivation more gratefully than either jute or Sunn hemp.

The *Ko Hemp* plant is a native of China and Japan, where the prepared fibre has long been woven into summer under-garments. The cloth keeps free from the skin under conditions when all other fibres cling.

Dunchi has been cultivated for many centuries by the natives of the marshy districts of India, and it is found all over the tropical regions of the Old World. The plant is a hardy annual, and the fibre is a good substitute for hemp.

Sisal plant [21] is grown extensively in the Bahamas, and is second only to Manilla hemp in value as a rope fibre. It is an attractive plant, with a thick bush of spike-pointed, fleshy leaves, and a straight, flowering stem rising from the centre. Sisal hemp is easily grown, and the fibre [22] is separated by a very simple process.

The fibre of the *Ochro*, or *Gombo*, is very white, strong and pliable, but the plant is grown for its fruit, which is used as a food, and the fibre is not much considered. It will grow almost anywhere in a hot climate, and should be a valuable source of fibre.

The plant known as the *Bola*, in Bengal, is one of those vegetable products which flourish best in conditions fatal to all others. On the sandy tracts of Northern India it grows profusely, and the fibre—a strong, useful substance, suitable for cordage and ropes—parts from the outer bark with little trouble.

21. SISAL PLANT
[Bahamas]

Varieties of Jute Substitutes. *Musk Mallow*, the seeds of which are useful to perfumery manufacturers, is a tropical plant of luxuriant growth, yielding a fibre of a quality resembling jute at the rate of about 800 lb. to the acre.

Bolobolo is a handsome flowering shrub, native to Sierra Leone, Senegambia, the Cameroons River, and the Congo. Closely allied to the jute plant, it yields a stronger, finer fibre, and would command a higher price on the market.

Sahadebi is a wild plant of the mallow family, growing abundantly all over India, and distributed all over the tropics. Closely related to jute, according to Dr. Watt, editor of the

"Dictionary of Economic Products of India," "its claims to superiority over jute are very considerable. The fibre is not half so coarse as jute, and it is of a much purer quality, and can, therefore, be spun into finer yarns."

Another rival to jute, of the mallow tribe, is the *Ran*, or *Banohendi*, generally supposed to be a native of the tropical zone of West Africa and tropical America, but found abundant in the damp lands of Bombay. It yields a fibre almost as soft as silk, 8 ft. to 9 ft. long.

Other Rope-making Fibres. The *Kanghi*, of Hindostan, a small mallow, distributed throughout the tropics, yields a strong fibre suitable for ropemaking. Its relative, better known as the *Indian Mallow* or *American Jute*, has a softer fibre, and is regarded as a jute by the Chinese, who produce large quantities of it. The plant flourishes over a wide area, both in Asia and North America, having become a troublesome weed in the middle States of the latter continent.

22. SISAL HEMP

Nilgherry Nettle. Belonging to the order *Urticaceæ*, and a near relative of the common stinging nettle, this plant grows in great profusion throughout the forests of the hilly districts of India, Burmah, and Ceylon. The stem is from 5 to 7 ft. long, and yields a fine fibre of great strength and high spinning value. Natives of the districts where it grows weave it into a cloth which strongly resembles silk. The season for cutting is between August and September. After being cut, the stems are stripped of leaves and dried in the sun. Dried hard, the stalks are boiled for twenty-four hours with wood ashes, and then washed with water. This preparation separates the fibres from the rest of the stem, and the long tresses are dried again in the sun. When dried, the fibres are spun into yarn or made into cordage. The yarn is woven into a fine cloth of wonderful texture and durability. Like most plants which seem to be candidates for textile honours, the Nilgherry nettle has had its day of "booming." Of the excellent spinning quality of the fibre there never has been much question; but it has one defect which repels. Being a large and powerful nettle, it is covered with stinging hairs filled with a virulent irritant extremely annoying to the gatherers of the stems. Nor does the preparatory process altogether destroy this stinging property. From all accounts, it seems that the cloth would make a very good modern substitute for the shirt of Nessus, the stinging filaments passing into the body of the fabric. Perhaps some means might be devised for destroying the noxious quality, which, for the present, is sufficient to exclude the fibre from the European market.

Scarcely so well known as the Nilgherry nettle, and free from its main defect, though of the nettle family, is the shrub known to botanists as the *Debregeasia hypoleuca*, abounding in the western Himalayas, Afghanistan, and Abyssinia. Growing to a height of 9 ft., the stalk about the thickness of a man's finger, the shrub has potent claims upon the attention of users of bast fibres. When subjected to the same treatment as flax or hemp, the stem yields a strong fibre, white, clean, and delicately fine. Its textile qualities have never been thoroughly examined. Because it does not rot in water, the people of the lands where it grows use the fibre for fishing-nets.

Coir. Coir is one of the best known rope and mat fibres. It is derived from the unripe nut of the coco palm. Emptied of its succulent contents, the nut is immersed in water and retted for a period of six months. When taken from the pits, the nuts are denuded of fibre by beating with sticks. While yet soft, the coir is spun into yarn by the natives, and comes to this country in huge coils of hard, crinkled fibre. Being very light and strong, coir was used in the making of the earlier deep-sea telegraph cables. Lacking the flexibility of hemp, coir is best suited for ropes having a straight pull, and does great service on docks and quays. In many departments of industry coir has been displaced by wire ropes. Coir has found another outlet in mats, and for this the fibre has many good qualities. It may claim, indeed, to be the most serviceable of the mat fibres, combining durability with flexibility.

Of fibres which may be utilised in the production of ropes and cordage there is an almost endless variety, both wild and cultivated; but, in the majority of cases, the fibres are consumed in the localities where they are grown, and therefore can only be considered as remotely potential, not actual, sources of fibre supply. In the list given, we have kept within the limits of the practical. Many experienced manufacturers will accuse us of having far exceeded that limit; but the present is a time of rapid progress, and the resources of the world are being swiftly developed. The purely scientific abstraction of yesterday becomes to-day a powerful factor in industry.

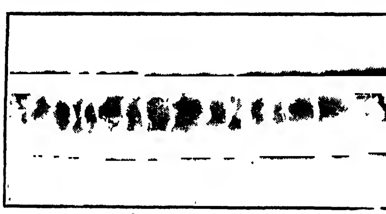
Continued

THE MICROSCOPIC STRUCTURE OF TEXTILE FIBRES

By William I. Hannan, Lecturer on Fibre Technology

EXAMINATION of the fibres of commerce under the microscope reveals distinctive features and explains in great measure the peculiar fitness of respective fibres for certain purposes. A glance at the properties of fibres revealed under great magnification will have an interest both practical and academic. The microscope is being called into service more and more as science is taking the guiding reins in modifying and developing modern industry. In the textile trades it has not yet attained the importance it possesses in the metallurgical and other manufacturing industries, but the tendency is all in the direction of greater knowledge through its instrumentality.

Wool. The illustration [25] shows wool fibres under a high state of magnification. The centre fibre has well-developed scales, that are almost closed and overlapping on the surface of the fibre when the yolk or suint has been removed. But here and there, on the left-hand side of the picture, are a few dot-like interruptions, which are evidently particles of natural yolk. The centre fibre is a fine specimen of a well-grown wool fibre, and the next fibre to it shows a graceful bend which extends over the greater part of the field. The third fibre has a stouter appearance, with a dense structure, and, as it is crossed by the fourth fibre, it is fairly well bedded underneath. The fifth fibre is crossed by two others of nearly similar thickness; and on the plate there is a translucent crossing of two fibres resembling a Maltese cross, which is always an object of interest when viewed with an objective with a clear penetration, such as the one used on this occasion. In the more highly magnified illustration [23], the photographer has brought into notice the typical structure of the wool fibre under the best natural conditions.



23. WOOL FIBRE
[Enlarged 294 diameters]

As the wool fibres are bent, the contraction of one side is not at all ugly, and the cylindrical part shows up well; and such fibres when treated properly in the machines they pass through, become well cleaned, and act well as they interlock and incorporate with companion fibres in the felting of the cloth.

Silk Fibres. Silk fibres, when seen under the microscope [26], have, on account of their transparency, been likened to a cylindrical glass rod. They are a wonderful development of the animal kingdom. Silk is a consolidated, flexible gum, and its value can hardly be overestimated in the textile industries. It is produced from two glandulose structures or *spinnerettes*, one on each side of the body of the silkworm. The silk fibre is thus a twin fibre, with a groove between the two parts, as clearly indicated in the photograph. This grooved structure is not visible to the naked eye, but is shown very plainly under high magnification. It is probable that the grooved structure adds strength, but, in any case, it allows the light to penetrate the body of the fibre and shows up the tinctorial hues and dyes which silk retains so well and which makes it so highly prized as a fabric of fashion. The fibres of silk may be distinguished from those of cotton or linen by the use of Schultze's solution, which is also the chief test for cellulose structures of the plant kingdom.

The character and structure of a silk fabric may be readily seen to advantage when viewed with a "Coddington" lens, which is of high magnifying power. If the details are not seen as clearly as desired, a microscope may then be used; but in all cases of raw fibres where specific and structural discrimination is desired, it is wise to carry a "Coddington," or, at least, a triple lens, in order to bring out details not easily seen with the naked eye. The "Coddington" lens is used by many yarn agents, cotton and silk manufacturers, buyers, and some cotton brokers.

Fibrine is the chief constituent of silk. It is surrounded by a coating of albumen, which is, in turn, covered by a layer of gelatine. Other constituents of the silk fibre are fat and some colouring matters. The waste of silk is known as *flourette* and *bourette*.

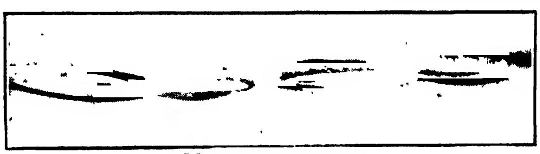
Cotton Fibres. Cotton fibres must be seen under the objective of the microscope in order to observe the natural convolutions of the cell fibre, upon which the real spinning qualities depend; and this method of examination is more important than the price paid in the cotton markets. At many of the best secondary and technical schools in Lancashire the structure of fibres is not clearly taught. Young men trained in such schools accept important situations where fibres have to be dealt with and judged every day, and they lack a knowledge of fibre structure; while young Germans, thoroughly instructed in this important department of textile technology, step into the same office and push them aside.

A glance at 27 shows most clearly the highest stage of development which a cotton fibre can undergo. The fibres shown were "alive" on the cotton seed not long before being photographed. The terminal parts of the fibres are not shown on the plate, but if they were they would mark out the solid end of the fibre which is unsuitable for spinning, and is, therefore, cast out. The solid end referred to has been styled the *cone* of the fibre.

At the top of the photograph are two fibres of special interest. That on the left-hand is fully ripe, with a spiral outline, and at every necklace-like division there appears a dense mark, which

represents the inner colouring matter of the protoplasm, which has been termed the *Endochrome.* This colouring matter is almost entirely absent in many of the American cotton lint, staples, and fibres. The brown Egyptian cotton fibres so highly represented on the field in incumbent positions, show the colouring matter well, and may fairly represent the fibres of the brown yarns, of fancy twists, and wefts. One of the fibres near the centre of the plate curved to the left shows a broad diameter in the middle portion, and is typical of East Indian cotton fibres generally. At the bottom of the plate are two fibres with a uniform diameter, one curved to the right and the other to the left of the plate. This feature is characteristic of the American group of cottons, and the fibre area, highly magnified [**24**], shows the clear cell and wall. The fibre on American cotton seeds is persistent, and when the lint has been removed a downy coating of shorter fibres invests the seeds. This coating is sometimes used for paper-making, and in commerce the name of *Shakers* has been given to it. There are no stomata in cotton fibres, not even in the one separately photographed and so highly magnified.

Flax Fibres. In the illustration [28] there is shown an example of the bastose tissue fibres of the well-known flax of commerce. The fibres, when in a young state, are centred in the inner tissues of the straw-like structure of the stem, and when the cortex or outer tissue has been removed by a process of retting, which has a destroying action on the over or outer coat of the stem, we have the fibres as shown.



24. COTTON FIBRE
[Magnified 294 diameters]

The plant is an annual, but it grows fast, and the fibrillous root hairs pick up quickly the food in the soil, and transform it into the protective and reserve tissue material.

The photomicrograph shows the character of the structure which facilitates the spinning qualities of flax. The fibres, as seen on the plate, are round and taper to an exceedingly fine point at each end. They are almost mucronulate. From the fine-pointed ends the fibres are broader, as may be observed, and of hard bastose consistence, with numerous pits or depressions. The presence of these pits prevents the fibres, when contiguous, from slipping, and this makes flax similar in its cohesive qualities and behaviour to cotton.

It must not be forgotten that the flax fibre is a multicellular structure, and is endowed with properties which cotton does not possess; therefore, flax must be regarded as a *true fibre;* while cotton has a single-celled structure. Commercially, however, flax is commonly termed a "linen fibre." The natural structure of the flax fibre facilitates spinning and weaving, and imparts the peculiar and valuable properties distinguishing *true* linenwoven fabrics. The flax fibres have an incumbent tendency in the cloth, and this has much to do with the secret of making the finest and most durable fabrics that can be woven.

Jute Fibres. The fibres of jute are obtained from the bast tissue, the most strengthening portion of the stem of the jute plant. They must be styled *bastose* fibres in contradistinction to those of cotton. The surface hairs of the cotton seed are intended to transport the seed when thoroughly mature.

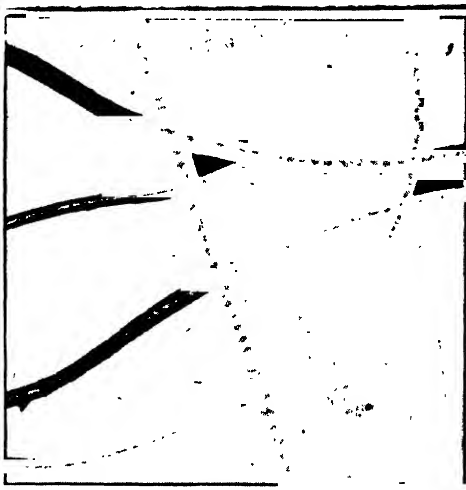
Jute fibres have been compared to gas and water pipes. The finer cellulose features may be likened to the micellæ of fine tissue which has only partly undergone the woody change in the cell wall and tissue structures. The fibres are strong, and they owe their strength to the structural parts of the tissue and the glossy, silky tissue of the cells which have become solid.

When the cells have undergone their hardening process, the vital or protoplasmic, active element of the cells may move to other important building-up parts, and so leave a cavity or space, which imparts value in the spinning properties. This hardening of the cell tissues may be compared to the grand period of growth that takes place in a cell wall when it arrives at its mature stage of development.

The strength and distending property of hard bast fibres of jute, ramie, and, in a less degree, of flax, must depend on and has been compared in mechanical structure and fineness to steel. Nevertheless, the fibres of jute and similar plants are found to be the best cellulose material for pliability, elasticity, and cohesion in the making of cordage and fabrics to stand hard wear, and for strings for spindle wharves. The fibres in **29** are good examples of the jute fibrous structure. It must always be remembered that the strength and fineness of the tissues are the chief factors of jute fibres.

Ramie. Under the microscope, ramie appears as a flattened tissue structure, with very delicate transverse markings. In the illustration [30] there are some fibres with faint lines apparently longitudinally striated, and if these depressed lines were constant in the tissue we should have a stem structure that would compete with that of cotton fibre. The faintness of the markings on the stem or bastose tissues probably causes the fibres to be so highly polished, and so tender in the bend. The same characteristic imparts the fine elasticity when stretched, and causes them to break with an extreme springiness when distended beyond their tensile strength, but they pull finely when skilfully drawn out with the fingers of both hands. When these fibres have undergone a bleaching process, the faint markings seem to be suppressed, and the lustre shows up much better.

The ramie of commerce has its fibres always centred in the stem structures.

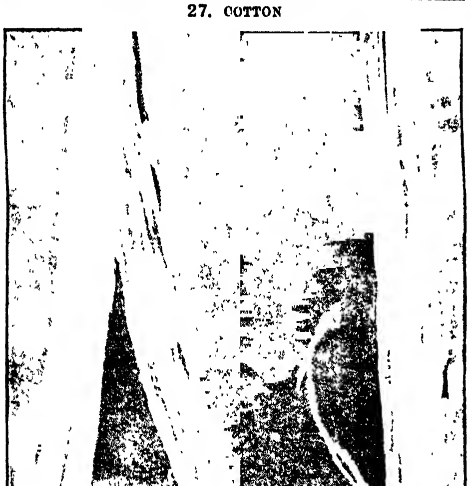


25. WOOL

26. SILK

27. COTTON

28. FLAX



29. JUTE

30. RAMIE

Photos by] PHOTOMICROGRAPHS OF TEXTILE FIBRES ENLARGED 107 DIAMETERS [*Mr. Edgar Senior*

WHAT DARWIN BELIEVED

Darwinian Theory of Evolution. Doctrine of Natural Selection. Facts on which the Doctrine is Based. Adaptation to Environment. Formation of New Species

Continued from page 651

By Dr. GERALD LEIGHTON

THE Darwin theory of organic evolution was given to the world simultaneously by Charles Darwin and Alfred Russel Wallace in the year 1858. These two great naturalists had been working quite independently upon facts which they had collected in entirely different parts of the world, and, as the results of their independent consideration of these facts, they reached a common conclusion as to the mode of origin of the various species of animals and plants now found in the world. The history of the publication of these views is one of the most interesting pages of scientific records.

How Darwin Changed the Trend of Thought. It is not too much to say that the publication of Darwin's views has changed the whole trend of thought in the modern scientific world. At first his opinions were received with strong and even bitter opposition in many quarters, especially after the issue, in 1859, of "The Origin of Species;" but from that date to this they have gradually gathered support from all educated people, until now either Darwinism, or some view of organic evolution which has been built upon Darwin's work, is held by everyone who has taken the trouble to make himself familiar with the facts of biology. A theory which has achieved such a result, which has altered our conception of things in almost every department of life, demands careful attention, and must be studied somewhat more fully than others which have been more or less discarded.

Although Darwin accepted the theory of Lamarck to a certain extent, he very clearly perceived that it was totally inadequate to explain all the facts. He was also of opinion that acquirements may be transmitted to offspring, and play their part as factors in organic evolution. But he also saw that parental surroundings and environment could not be the sole cause of the variations of offspring, or else a litter of puppies all born from parents having the same environment would all inherit the *same* acquirements. Instead of that being the actual case, Darwin noted that such puppies might be superior or inferior to their parents in regard to particular qualities, and that they might present entirely new variations. He deduced from cases of this kind the opinion that there must necessarily be some other reason or causes of variations in offspring than merely the transmission of the acquired characters of the parents. On that undoubted fact he based his theory.

From this deduction he proceeded to enunciate the doctrine which will ever be associated with his name—*viz.*, the doctrine of *Natural Selection.*

What Natural Selection Means. It is to be noted that Darwin did not attempt in his theory to account for the differences or variations he found to exist. He simply noted the fact of their existence, and pointed out that some of them could not be attributed to the transmission of acquired characters. In the absence of any adequate explanation of these variations they were termed *spontaneous* or *accidental*, in the sense we have already explained. Darwin then came to the conclusion that Nature acted as a breeder would do, selecting certain of these variations from which to continue the race, and rejecting others. Those which were rejected were in time eliminated. He supposed that as a general rule Nature selected the *superior* individuals to continue the race, the superior individuals being those which possessed some variation which rendered them particularly well adapted to the environment in which they found themselves. He was driven to the opinion that some sort of selection was at work by ascertaining that the number of individuals in any species of plant or animal which survive and have offspring of their own is not identical with the number that come into the world. Some disappear.

The question which suggested itself to him was, Which individuals do not survive, and why are they the ones to be eliminated? The answer which forced itself upon him was that the survivors must be those which are better fitted to their surroundings. Nature selects these and eliminates the less fit. This is Darwin's doctrine of natural selection.

The Struggle for Existence. For a considerable time there were many people who could not, or would not, see the necessity for some kind of selection among offspring. Indeed, there are still a few who deny the struggle for existence. They are an ever-diminishing number, and in view of the facts of the case it is very difficult to account for such an attitude.

In the first place, it is perfectly obvious that there is only a limited amount of space on our earth which is habitable for any given species. There must, therefore, be some limit to the number of either plants or animals which can "make a living" at any given time. A certain number only, from the nature of the case, can exist together. In the next place, it is a simple fact that every living creature tends to increase in numbers, some more rapidly than others, but all more or less rapidly. Yet if we examine any given species in a certain locality we find that, in spite of this fact of continuous and uninterrupted reproduction. the total number of individuals in that locality remains fairly constant. There may be some increase or some

decrease, but, speaking generally, the numbers do not change to a great extent unless the surroundings also vary. It follows that some kind of check must be operating to keep the numbers within limits.

Nature's Checks on Overcrowding. Let us take an example to illustrate this point. The elephant is an animal which increases in numbers with the *minimum* rapidity. It has a family of six only during a period of some sixty years on an average. An individual elephant lives for about one hundred years. If every elephant which is born survived and had the average number of offspring, the result would be that we should find a *total of about nineteen million elephants descended from a single pair after the lapse of from* 740 *to* 750 *years.* This, be it noted, in a species which breeds with extreme slowness. Such a result, of course, does not occur.

Still more striking would be the result in the case of an animal which increases with great rapidity. Take the case of the field vole. This little mammal produces several broods during the same summer, and some of these young ones in their turn breed before the winter. It has been calculated that if there were no checks to the increase of the field vole, *a single pair* of these animals, supposing their first brood to be born on April 15th in any given year, would produce by October 8th following no less than 193.

Occasionally it does happen that the ordinary causes which keep down these numbers fail to operate, with the result that enormous numbers make their appearance in certain localities, doing extensive damage to crops. Such seasons are called " vole years." A similar phenomenon is seen sometimes on the introduction into a new country of a species which in its native land was kept down by natural checks. These checks may not be operative in the new habitat, and the result is the enormous mulitiplication of the introduced species. The rabbit in New Zealand and Australia is a case in point. The sparrow in the same countries is another.

Life is a Constant Fight for Life. Since this enormous and phenomenal increase in numbers of offspring stated above *does not take place* under ordinary conditions, it follows that there must be some kind of very stringent means to prevent it. There is not room nor food nor opportunity for all to survive and multiply. In other words, life is a constant fight for life ; it is, in the language of the Darwinian theory, a constant *struggle for existence.* Every single plant and every single animal which is living under natural conditions is continually engaged in a more or less keen competition with others of its own species, and also with other kinds of plants and animals. Not only has the plant and the animal to compete with plant and animal, but each has also to struggle against the ever-changing climatic conditions which form part of its environment. The living have to contend with the non-living physical forces around them as well as with the competitors of their own kind. The inevitable result is that those individuals which for any reason surpass others in this continual struggle with environment are the individuals which survive and perpetuate their kind. They are *naturally selected.* The battle is to the strong. The weak go to the wall. In a word, the keynote of Nature is the *survival of the fittest by natural selection in the struggle for existence.*

Who are the Fittest? It must be carefully borne in mind that the term *fittest* in connection with organic evolution has a definite meaning. It does not mean exactly what is implied in the everyday use of the term: It does not necessarily mean what we might be inclined to call the *best.* It means the best in a biological sense only. The term refers to the individual and his surroundings. It means that individual which is most fit for the environment in which it is placed ; best in that sense. Since all individuals vary somewhat, it follows that some are more fit—are better, in this sense—for the particular environment in which they find themselves. It cannot be otherwise ; it is an everyday experience. As long as the environment acts upon all alike, as it does under natural conditions, it follows that the fittest will survive, while the least fit are eliminated.

The other factor which completes the Darwinian theory is the influence of heredity. No one can possibly deny the fact that *certain characters* can be and are transmitted from one generation to another. Darwin believed that natural selection operated in the direction of choosing in a species those individuals which had varied in a way which gave them some advantage over their fellows, and that their favourable variations were transmitted to their offspring. He did not, it will be remembered, attempt to account for these favourable variations. He termed them spontaneous.

But he came to the conclusion that, no matter how these variations originated, the individuals showing variations which adapted them to their surroundings would have the best chance of surviving and having offspring. They would be the fittest to survive in the struggle for existence. The result of the mating or pairing of individuals thus favoured would be to hand on to their offspring their useful variations by means of heredity, and as these advantageous variations accumulated, there would ultimately be produced creatures which would constitute new varieties or new species. The selection by Nature was thus a selection of useful or advantageous variations which were transmitted to offspring by heredity.

The Simple Meaning of Darwinism. These useful variations, Darwin thought, were generally slight in amount, but sufficient to confer upon their possessors some advantage in the struggle for existence. In the case of the antelope, for example, those individuals which possessed slightly more endurance, speed, scent, and so forth, would be better able to survive than their less-favoured brethren ; they would therefore be selected, would hand on advantageous variations to their offspring by means of heredity, and so in time there would be evolved the creature with which we are familiar.

This, put in the simplest way, is the meaning of Darwinism. It does not mean, any more than does evolution, that man is descended from a chimpanzee. It accounts for the origin of species by natural selection. Before considering other points in connection with this view we may conveniently summarise the whole theory.

Two Facts and Their Meaning. Darwinism is founded upon two well-ascertained facts from which two inferences are deduced.

The *facts* are as follow:

(*a*) The universal occurrence of variations in individuals of every species.

(*b*) The number of individuals in any species which survive and beget a full quota of offspring is not the same as the number of individuals which come into being, great numbers perishing before reaching either maturity or old age.

The *inferences* are these:

(*a*) As a rule the individuals which survive and have offspring are those which are better fitted to the environment in which they are placed than are those which perish.

(*b*) By this survival of the fittest in the struggle for existence and the consequent elimination of the unfit, the average of the race is raised in successive generations by means of heredity, the result being the gradual evoluti n of living creatures.

A very clear way of stating the theory is that of Professor Ainsworth Davis, which is as follows:

PROVED FACTS:

Limited surface of globe and rapid increase in numbers.
Struggle for existence and variation.
Natural selection and heredity.

NECESSARY CONSEQUENCES:

Struggle for existence.
Natural selection, or survival of the fittest.
Origin of new species.

Can Acquired Characters be Transmitted? We have now stated in the barest outline the two great theories of organic evolution—the Lamarckian and the Darwinian theories. At present neither of these theories is held, to any great extent, *in quite the same way*, or in the same terms, as those in which they were originally propounded. Much has happened in the scientific world since Darwin gave the world the theory of natural selection, and his modern followers, while accepting his main contentions, declare that he underrated his own discovery.

It will be remembered that Darwin simply accepted the undoubted fact of universal variation without attempting to account for it, and at the same time denied the teaching of Lamarck that it arose entirely from the transmission of acquirements. His modern followers, the Neo-Darwinians, go much further, and declare not merely was Lamarck partly wrong, but that he was wholly wrong in this matter. They assert that acquired characters are *never* transmitted. They believe that Darwinism does more than account for organic evolution partially—that it does so entirely. They strenuously deny Lamarck's view of the origin of variations which Darwin thought might be *partially* true.

Working of the Darwinian Theory. It will be well, for the sake of clearness, to give some illustrations of the application of Darwinism, just as we did in the case of Lamarck's theory. The central idea, be it remembered, is the natural selection of small favourable spontaneous variations. Living beings, as a rule, are so well adapted to their surroundings that great variations and abnormalities are not advantageous, but rather the contrary. For that reason they tend to die out in a few generations. Thus, a man's hand may vary from that of his father in the possession of a sixth finger, a great variation or an abnormality which is of no use, and which in a few generations disappears. Usually the difference is in size, strength, or texture—*i.e.*, small variations. The followers of Darwin suppose that all structures began originally as slight variations from pre-existing ones, and that the complex organs were evolved by the gradual and continued addition of small variations.

According to this view, the antlers of deer would originate thus. Amongst the hornless ancestors of deer there would be some which varied from their fellows in having thicker and stronger frontal —*i.e.*, forehead—bones, and these, by pushing and butting with the head when the struggle for mates took place, would be the more successful. They would be the individuals selected to carry on the race. In their offspring the thick and strong frontal bones would be still more marked, and, through the survival of the fittest and heredity, there would be gradually evolved deer with small bony prominences on the forehead. By the still further accumulation of slight and favourable variations in this direction, antlers made their appearance, and continued to enlarge so long as the enlargement was of a useful character, but no further.

The Neck of the Giraffe. The theory of Lamarck would account for the extraordinarily long neck of the giraffe by saying that giraffes were in the habit of stretching their necks to feed on branches of trees, and that this stretching lengthened the neck of the individual; the individual then handed on this acquired extra length of neck to his offspring, and thus there arose long-necked giraffes.

According to Darwinism, however, the long-necked giraffe is due entirely to a natural selection of individuals who were born with longer necks than their fellows, and had thus the best chance of survival in their particular environment. In times of great scarcity of food the shorter-necked individuals would be at a disadvantage in the matter of food, and the propagation of the race was therefore left to the long-necked individuals. This process, continued through many generations, would gradually result in the production of the modern giraffe as we see it.

The Speed of Hares, and other Examples. One or two other cases will bring out the contrast between the two views still more prominently. "Lamarckians believe that hares run swiftly because their efforts at swift running developed the appropriate structures, and this improvement, transmitted and increased generation after generation, resulted at last in that very swift animal, the modern hare. Neo-Darwinians contend that the great speed of hares is due to the fact that those animals who were *naturally* the swiftest escaped their enemics, and that by this means, during the process of ages, was the swift modern hare evolved. Say they, all animals other than giraffes also stretched upwards for food, yet their necks did not grow long; all animals other than hares strove to run fast, yet they did not become so speedy. On the contrary, their survival was secured by evolving in other directions. Lamarckians assert, but Neo-Darwinians deny, that the child of him who does hard manual labour tends to have at birth thicker skin in the palms than the child of him who labours only with his brains.

"Neo-Darwinians say that a *naturally* tall man tends to have tall children, but that, no matter how a man is stretched or how he stretches himself, his children will not be the taller in the smallest degree for the stretching. Lamarckians affirm that they will. Lamarckians maintain that if a blacksmith increases the size of his muscles by labour his children will thereby profit, and have stronger muscles than they would otherwise have had. Neo-Darwinians deny this. Lamarckians affirm that if a man develops his brains by study his children will have better brains for this purpose. This, again, the Neo-Darwinians deny. Lamarckians maintain that if a man has children, and then, after falling into ill-health, has more children, the latter will be more feeble than the former. This, yet again, is denied by Neo-Darwinians." (*Dr. Archdall Reid.*)

The Theories Compared. Having broadly stated the two great lines of thought concerning organic evolution, the Darwinian and the Lamarckian, the next step is to compare and contrast these theories and weigh the evidence for and against.

All other theories of organic evolution are, more or less, modifications of these two, in spite of what their authors may say to the contrary. It must be so from the nature of the case. There are only two possible roads which can be followed, although there are side-paths to these roads. Organic evolution must proceed either by the transmission of inborn characters from parent to offspring and by their accumulation during successive generations, or it must proceed by the transmission of acquired characters in the same way, simply because no other kinds of traits exist in living organisms but these two groups. Whatever name, therefore, may be given to a theory brought forward, it, of necessity, is either Lamarckian or Darwinian in essence.

Enough has been said, and sufficient examples given, to show that these two views of organic evolution are in violent opposition and violent contrast.

Agencies of Evolution. In the first place, we are struck with the fact that Lamarckianism attributes evolution to the operation of beneficial agencies. It supposes that good food, fresh air, healthy moral and physical surroundings, exercise, and such factors are the cause of evolution by the handing on of acquirements to offspring, as seen in the examples quoted. In the same way, the theory supposes that the injurious agencies would cause enfeeblement and ultimate degeneration and destruction of the race by injuries or disease handed on to offspring and accumulated.

On the other hand, Darwinism attributes organic evolution, not to beneficial agencies, but to *injurious* ones causing a selection of individuals. This is a profoundly important matter, and one which bears directly upon the problems of social welfare. Note most carefully that *it is not every injurious agency which can act as a factor in evolution.* It must be one which is sufficiently powerful to separate the fit from the unfit, to discriminate between what is superior and inferior in any given environment. In other words, according to Darwinians, these injurious agencies must be *selective* in order to cause organic evolution.

Selective Agents. Under the influence of factors which are sufficiently potent to cause selection of individuals of a given type, the fittest will inevitably be those who will survive and continue the race. The other less favoured individuals will to a great extent be eliminated. "It follows, if an injurious agency is so little injurious as not to influence the death (or birth) rate, or so very injurious as not to discriminate between the fit and the unfit, that it cannot be a cause of evolution. In the one case the unfit are not eliminated; in the other the fit do not survive." (Reid.) We see, therefore, that what are called accidental deaths cannot affect the cause of evolution. For example, deaths by drowning, or fire, or in warfare, although they are responsible for the loss of many lives, do not cause evolution, because they are not selective. A bullet does not select the fit or the unfit. Both alike succumb. So fire and water do not select any special types of individual for survival, and are therefore not selective agents in the evolutionary sense.

Stringent selection is therefore the Darwinian explanation of organic evolution, whereas the Lamarckian theory attributes evolution to the action of beneficial agencies upon a species. According to Darwin an injurious agency will act by eliminating the unfit; according to Lamarck it will cause degeneration by transmission of acquired effects of weakness.

Nature and the Breeder. It is a remarkable and interesting fact that during every age those who have been engaged in the breeding of plants and animals have held the beliefs of Lamarck (whether consciously or unconsciously), but have *acted* upon the

Darwinian theory (knowingly or otherwise). The Lamarckian idea of the transmissibility of acquired characters is universally believed by the mass of people who have not carefully made inquiry into the evidence for and against. And yet even those who are convinced of its truth never think of applying it in actual practical breeding experiments.

Putting aside the beliefs of the plant or animal breeder—which are of no importance—consider his plan of action and note the result, which is of great importance. Suppose that he starts out with the object of producing a plant or animal of some special type, having some definite quality which is desirable for some purpose. He knows quite well that he cannot improve a species in all sorts of directions at the same time, and he does not attempt to do so. What is his method of procedure?

He proceeds by making a stringent selection of those animals from which he intends to breed. What does he select? Does he pick out an individual which has acquired the special character he wishes to breed? Not at all. He selects individuals which have varied *naturally*, *spontaneously*, in the required direction, and he mates them. Suppose that the horticulturist wishes to produce a strain of flowers of a given colour. He does not endeavour to make a plant acquire that colour by growing it in certain soil and watering it with certain pigments or manures, in the hope that the plant after acquiring the desired colour will produce offspring similarly coloured. What he does is to select individuals which have varied naturally in the desired direction, and reject the rest. He eliminates those unfit for his purpose and breeds from the fit. He must be content to improve his stock in a few directions only.

Man as an Agent of Evolution. How can a breed of racehorses be established or produced? Does the breeder take a horse of ordinary speed and proceed to train it by food and exercise until it is able to gallop a mile in a given time, and then breed from it, in the hope that this acquired faculty of speed will be transmitted to the offspring? Not at all. The breeder observes that some horses are *born* with a greater capacity for speed than others. They are naturally, spontaneously, faster. He makes a stringent selection of such individuals and rejects all the rest. He finds that these inborn characters will give him the desired result, whether he knows the reason or not.

If the Neo-Darwinians are right, the same thing must occur in natural selection, and in that case the evolution in animals and plants could not take place in many directions at the same time. It is quite true that living species are very highly organised, and that they must have undergone evolution in all their characters, but not in all at once. For example: "For thousands of years the eyes, the ears, the hands, the feet, and very many of the characters of man, have undergone no appreciable evolution. They were evolved during different but overlapping periods of a long extended past." (Reid.)

"The proofs furnished by breeders are too conclusive. It is quite beyond dispute that offspring differ innately from their parents, that these innate differences, these *variations*, are transmissible to descendants, and that if advantage be taken of them by selecting for breeding purposes the superior individuals, while the rest are eliminated, evolution will result. The only point we have to prove is that Nature, like the breeder, exercises the necessary selection." (Reid.) This brings us to the objections to the doctrine of natural selection, which we must now examine.

Two Objections to Darwinism. There are only two serious objections which the supporters of the doctrine of natural selection have to meet. Very few scientific men hold either of them, but they are still advanced by some, and must be considered. The first objection is that acquired characters can be transmitted to offspring, and that Darwinism does not therefore explain all the facts. We shall refer to the evidence upon this point in detail when we approach the problem of heredity.

The second objection advanced by some is a more difficult one to answer. It is that Nature does not act upon the same lines as the breeder, that no real selection is made by Nature, that she works at random amongst variations; in fact, that there is no such thing as a true natural selection of the fittest in a struggle for existence. These objectors affirm that such a selection could only be made by a conscious individual such as man, and that such a selection as he makes for breeding purposes, an artificial selection, has no counterpart in the processes of Nature.

Does Nature Really Select? It may be admitted at once that it is a matter of some difficulty *to prove* definite cases of selection by Nature amongst the wild plants and animals. The reason is that we are not sufficiently acquainted with all that happens in their whole life-history. However reasonable it may be to believe that advantageous variations are selected by Nature, it is very difficult to point to actual cases in wild life, though the evidence from many sides is very conclusive as to its occurrence. But if we can prove that natural selection has acted in a very definite manner along the lines suggested by Darwin in any one species, we may reasonably conclude that such a method of action is applicable to other species.

Curiously enough, the animal which has been most neglected in this inquiry is the one best known to all men—*viz.*, Man himself. If natural selection has been the great agency of organic evolution, we surely ought to find some striking evidence of its operation in the production of its greatest result. Is it possible, then, to point out how natural selection has affected the evolution of man himself, and is still so doing?

Continued

Group 12
MECHANICAL ENGINEERING
6
Continued from page 686

MECHANICAL ELEMENTS APPLIED

Levers, including Air-pump and Spring Levers, Cranks and Eccentrics, Wheel-gearing and Cams. Wedges and Screws

By JOSEPH G. HORNER

WE now give a number of selected examples of mechanism illustrative of the application of the skeleton force diagrams which were embodied in the last article. The levers there shown are simply the lever crank chains of Reuleaux, and the arms are the links turning about permanent centres. The skeleton lines have no relation to the actual shape of the mechanisms, they simply give relations, ideas, as evidenced by the differences in an engine beam, a crank, a toothed wheel, an eccentric, etc. The student should exercise his faculties in tracing out the elements of mechanics through other diverse forms.

Examples of the Lever. Levers of the so-called first order [58, page 686] occur most frequently. The most familiar form after the common pair of scales is that of an engine beam, in which the arms are equal on each side of the fulcrum, or central pivot, and the loads equally balanced; that due to the steam pressure on one side, and the resistances offered by the connecting-rod and flywheel on the other. As the greatest stresses come on the beam at the centre, due to the *leverage* exerted by the arms, the double parabolic outline is adopted, a form which, varied with plain tapered outlines, recurs constantly. Such a lever is subject to forces tending to snap it off near or through the fulcrum, and therefore the thickness of metal, in cast iron, has to be very liberally proportioned. Such beams have frequently broken after years of service. A terrible colliery accident once resulted from such a beam breaking. In the older engines, timber was used largely; in modern practice, mild steel plates are commonly used for beams, large and small alike, two or more being laid parallel, with distance pieces intervening.

Air-pump Lever. An unequal-armed beam, a lever of the first order, is illustrated in **72**, being an air-pump lever for an engine of marine type. The usual proportion for such levers is 2 to 1—*i.e.*, the air-pump piston has just half the stroke of the engine piston. The load upon the pump end of the lever is found by multiplying the area of the pump piston or bucket by 30 lb. per square inch. This latter figure makes allowance for the various frictional resistances as well as the load due to suction, etc. Then, applying the principle of the lever, the load on the engine end is

$$\frac{\text{Area of pump piston} \times 30 \times A}{B}$$

A being the distance of the pump end from the pivot fulcrum, and B being the distance of the engine end from the fulcrum. The pins, bearings, and rods can then be designed to suit the resulting loads. The fulcrum pin has to sustain both loads as well as the weight of the work itself.

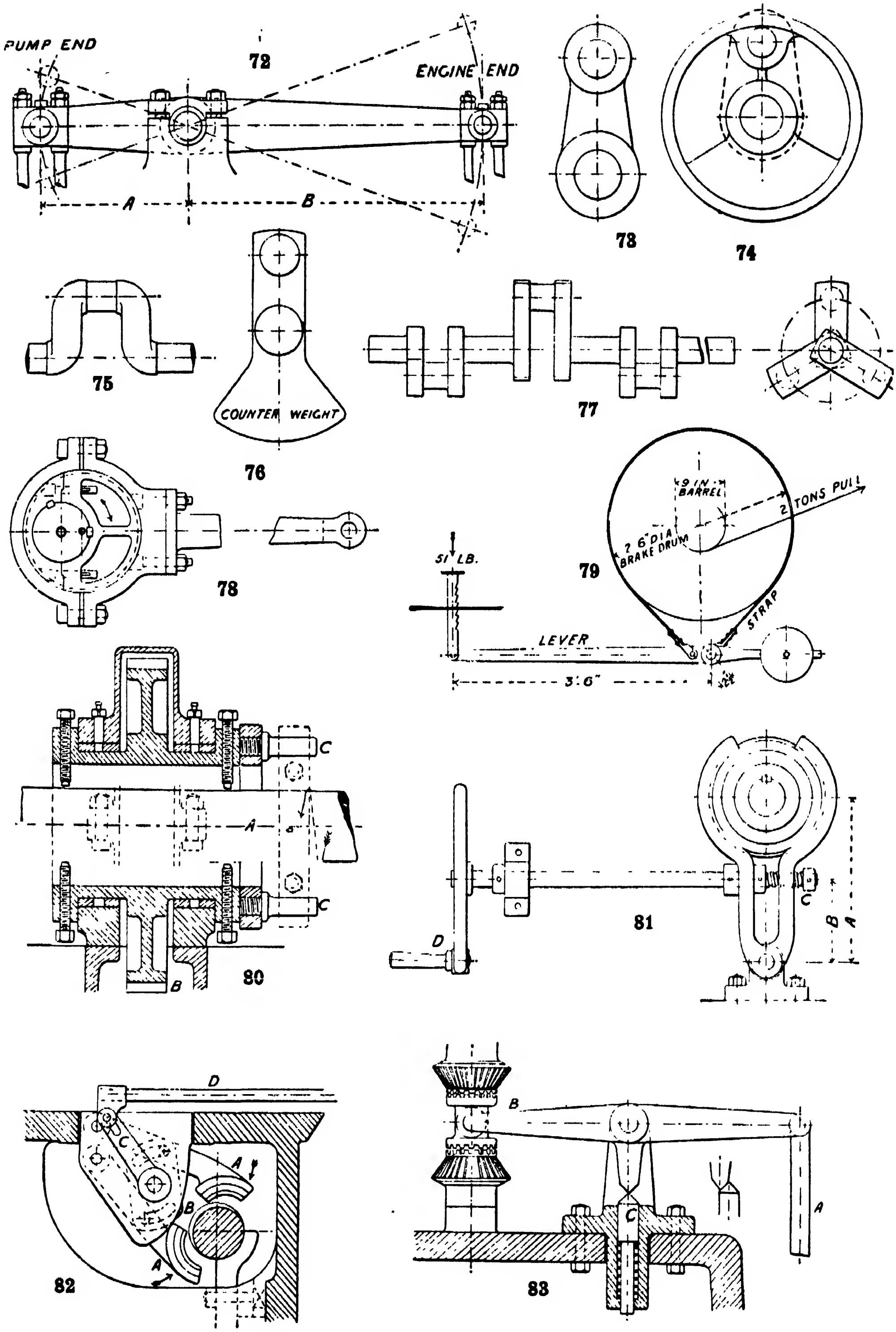
Cranks. An engine crank [**73**] is one of the most familiar examples of the same group of levers. But here one arm is absent, so that it is a disguised form. But the deficient arm is provided by the resistance which is set up in the engine shaft by the driven mechanism, and which the crank has to overcome. A crank shaft is therefore subjected to severe torsion, just as though a massive weight were suspended from an arm attached to its circumference. The crank disc [**74**] is exactly the same element, as is clearly seen by the outlining of a crank on its face. The disc form has nothing to do with the twisting stress on the shaft, but the circular shape is imparted in order to obtain a counterbalance to the crank to enable it to rotate without a jerky movement, which counterbalance does not exist in **73**.

The bent crank in **75** is another example of a one-armed lever, the resistance to which is embodied in the crank shaft. As such cranks are liable also to jerky movements, they are often counterbalanced by other leverages. Thus, to counterbalance locomotive cranks, heavy weights are inserted in the driving wheels opposite to the crank pins. Two-cylinder compound marine engine cranks [**76**] often have weights formed as extensions of their webs. But for these provisions, locomotives would knock themselves to pieces when running, and compound marine engines would be subject to excessive vibrations.

Often the one-armed crank is balanced by other similar cranks in the same mechanism. Thus a pair of engines are set with their cranks, not in line, but at right angles, or sometimes diametrically opposite. Treble-barrel pumps have their cranks arranged in the three-throw style, or at angles of 120°, to balance each other [**77**].

An eccentric [**78**] is a crank, and therefore a lever, only the fact is disguised by the *throw*, and by the fact that the equivalent of the crank *pin*, instead of being of relatively small diameter, as in **73-77**, is larger than the combined diameter of the shaft, plus double the eccentricity. The relation of the lever crank is indicated in the figure by the two small circles, centre of *throw*, and of rotation respectively.

Going from smaller to larger examples, the great lifting bascules of the Tower Bridge are levers of the first order. Only one arm of each bascule is seen, the other is hidden within its pier. The arms are of unequal length, the shorter being in the piers, but equality of moments is produced by increasing the mass



PRACTICAL APPLICATIONS OF THE LEVER

there, and adding counterweight, so that the long and short arms balance.

The application of the lever of the first order [58] to the common balance is obvious. But it is applied to a large number of weighing machines in which the arms are not equal, including the public weighing engines of the streets and platform weighing machines. An enormous disproportion is made between the long and short arms, and thus a very slight depression at one end is multiplied many times at the other, and communicated to the steelyard—another lever in the office.

Foot Brake. The second order of levers has a typical example shown in 79—*viz.*, a foot lever brake for an ordinary steam crane. The load on the brake band is, first of all, calculated by multiplying the pull by the diameter of the lifting barrel or drum, and dividing by the diameter of the brake band. The lifting drum in the example is 9 in. in diameter, the brake band 2 ft. 6 in., and the pull on the drum is 2 tons:

$$= \frac{2 \text{ tons} \times 2240 \text{ lb.} \times 9 \text{ in.}}{30 \text{ in.}} = 1344 \text{ lb.}$$

Only a portion of this comes upon the end of the strap that is operated by the lever. The exact amount depends upon the arc of contact which the strap makes with the brake drum, and upon the co-efficient of friction between the band and the drum. With a co-efficient of ·02, and an arc of three-fourths of a circle, the load will be approximately ·64 of the above sum $= 1344 \times {\cdot}64 = 860$ lb. Then, by the principle of the lever, the load on the foot treadle is

$$\frac{860 \times 2{\cdot}5 \text{ in.}}{42 \text{ in.}} = 51 \text{ lb.}$$

With a brake of this class, it is necessary to balance the treadle and lever so as to ensure the brake being released freely when the pressure is removed from the treadle. This is accomplished by forging an extension to the lever and securing a counter-weight thereon, the amount of which can be calculated by treating the case as a lever of the first order.

The construction of brakes of this class generally utilises the friction between wood—elm and poplar—and cast iron. The brake blocks are made in widths of from 3 to 4 in., and screwed to a strap of thin sheet iron, which makes a flexible element, capable of being wrapped both freely and tightly round the turned rim of the band-wheel. The lever, being subjected to severe bending stress, is a forging, and the counterbalance weight is generally cast with a hole to slide over the opposite end of the lever, to be fastened to it with a set bolt.

Axle-turning Head. An excellent example of a lever of the second order is shown in the drive of the Armstrong-Whitworth axle-turning lathe [80]. The fulcrum is at one end in the centre (A) of the axle which is being rotated. The power is at the opposite end, at the pitch line of the hollow toothed wheel (B) which rotates the axle, and the weight or load is at the circumference of the axle, being turned by a cutting tool there. The smaller the axle, therefore, the greater is the mechanical gain.

Power is gained also for turning the wheel by another lever, the driving pinion at the back (not shown) making with the wheel a pair of levers of the first order [58]. The pins (*CC*) standing out from the head are a Clement's driver, employed to produce equal driving movements about the axle being turned. Lathe men will recognise this as the familiar device adopted to balance the driving effort, and so prevent one-sided jerky movements of work about the centre.

Clip. The third order of levers is not nearly so much in evidence as are the first and second. Having no mechanical advantage, it finds applications only under peculiar conditions. An example is given in 81, in the form of a clip, that is used to prevent certain portions of machinery from revolving, and which is a useful detail when fitted to a derrick gear worm on a crane. The power to be exerted by the hand wheel and screw is, of course, determined by multiplying the pressure required on the clip by the distance A, and dividing by the distance B.

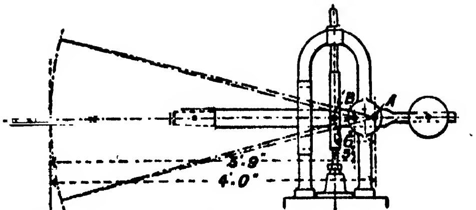
The illustration also shows the application of a screw (C) operated by a lever, the hand wheel (D) to gain sufficient power on the clip to overcome the turning movement of the worm gear. Here, as in the case of the lever [79] with long and short arms, enormous mechanical advantage is obtained by the exercise of the power of one man.

Clasp Nut. Fig. 82 is a familiar example of a lever of the same order—the Whitworth clasp nut. The hinged levers (A A) have the nut portions attached at one end (in the form of half-brasses), while the power to operate them is derived from the cam plate (B), the pins of which transmit power. The cam plate is attached to the lever (C), the handle (D) of which extends to the front of the lathe.

Spring Levers. There is a large number of levers in every order in which a spring is the element of either power or weight. They occur in the treadles of some forms of power hammers, and in the automatic trips of many machine tools.

Fig. 83 shows a lever trip of one kind applied to the reversing motion of a grinding machine. The rod (A), being moved by a dog at a certain stage of the table travel, throws the fork (B) and its clutch in either one or other direction, so putting the bevel wheels shown into engagement. To retain them thus, the spring plunger (C) has its end bevelled to match a bevel on one arm of B. The plunger is forced up as B pivots by the coiled spring behind it, when the bevelled faces lock.

Force Pump. Levers are made with movable fulcrums to suit different pressures, as, for example, in 84, where an ordinary hydraulic force pump is shown. Two fulcrums (A and B) are arranged by fitting a removable pin to the two holes in the framework. The short arms of the leverage available measure 6 in. and 3 in.



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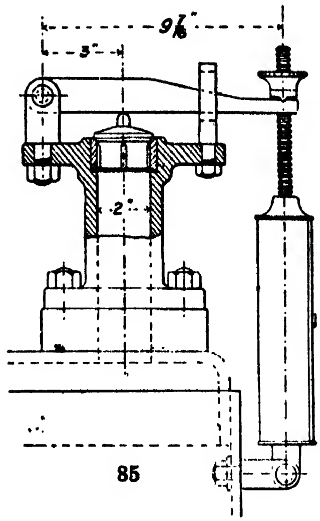

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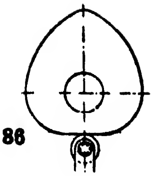

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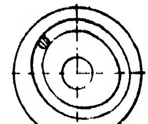

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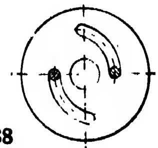

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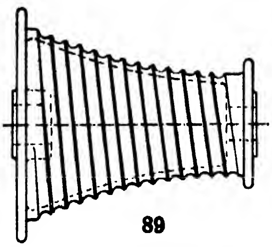

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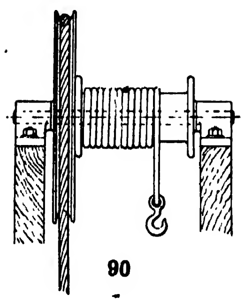

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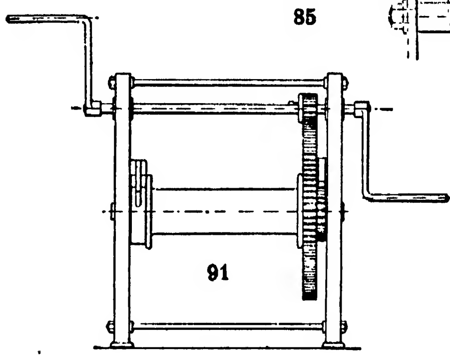

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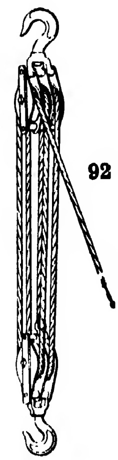

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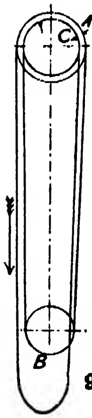

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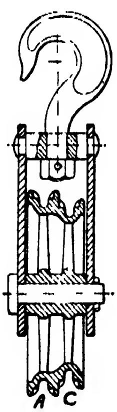

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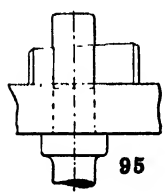

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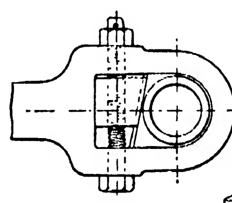

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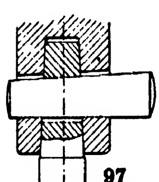

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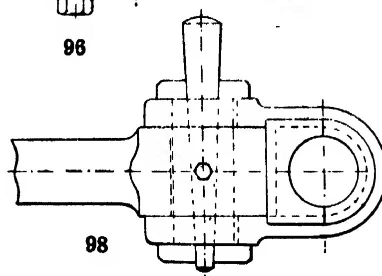

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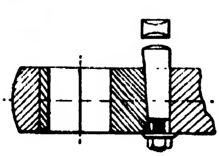

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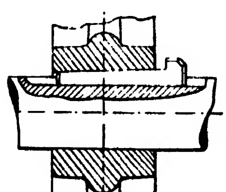

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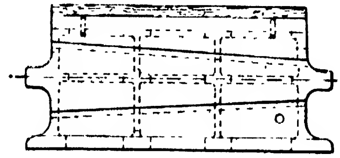


101

PRACTICAL APPLICATIONS OF THE LEVER AND WEDGE

respectively, and the long arms 48 in. and 45 in. respectively. When working on fulcrum A the mechanical advantage is $\frac{48 \text{ in.}}{6} = 8$ to 1. When the pressure rises and the work becomes harder, the fulcrum pin is moved to B, and the mechanical advantage becomes $\frac{45 \text{ in.}}{3} = 15$ to 1, the stroke of the pump ram being correspondingly shorter.

Safety Valve. A case where a lever is designed to give the load per square inch upon a given area is illustrated by the spring-balanced safety valve in **85**. The valve is 2 in. in diameter, and the spring of course records pounds. The proportion of the lever depends upon the area of the valve. If the valve were 1 sq. in. in area it is manifest that the recording spring could be placed directly over the valve, or fitted on a lever of equal proportions. If the valve was 2 sq. in. in area a lever of 2 to 1 would be required. A 2 in. diameter valve is 3·14 sq. in. in area, and so the lever is arranged in the same ratio. Fixing the fulcrum at 3 in. from the valve centre, the lever becomes 3 in. × 3·14 = 9·42 = $9\frac{7}{16}$ in. long. The spring safety valve is an alternative design to that, having a lever arm loaded with a weight.

Wheel Gearing. Toothed gears are disguised levers ; the teeth are only incidents, since smooth-faced wheels will run by friction. It is not necessary even that the radii should be constant, but radii and leverage may vary. And thus we have elliptical gears, triangular gears, square gears, and others, all transmitting variable but constantly recurring rates of motion.

It is an axiom in kinematic chains that they may be converted into mechanisms in as many ways as they have links, because any one link may be made the fixed one, leaving the others movable. This can be studied in the spur gears, which are levers, or turning pairs connected by means of the teeth, which in theory have line contact. In ordinary wheels the centres are fixed by bearings, and the rigid connection thus imposed is a mechanical link. There is no motion of the centres in space. In what are termed epicyclic trains, only one centre is thus fixed, and one or more revolve round it in one direction or the other, with a minute gain or loss in speed.

Cams. A cam is a lever, but with its arms of varying lengths, corresponding with the outlines imparted to the edge or groove, as the case may be. The centre on which the cam rotates is the fulcrum to the edge or grooves. In cams the lengths of arm vary, changing from maxima to minima, or passing through variable but irregular movements. In the modern practice of the engineers' machine shop they fill a place of constantly increasing importance, inasmuch as they take the place of movements otherwise effected by the hands of the workman, with more or less inaccuracy. The cam is both tireless and precise. Its movements can be relied on, for they are timed in the design itself. In feeding movements especially, the cam is of most value. It is embodied notably in the various automatic screw machines for controlling the relative movements of the tools and work.

Fig. **86** is a heart cam, giving variable but regular movements on each lobe. Fig. **87** is a grooved-face cam, giving an irregular motion, and Fig. **88** is the regular two-slot cam plate for clasp nuts, etc., another example of which occurs in **82**.

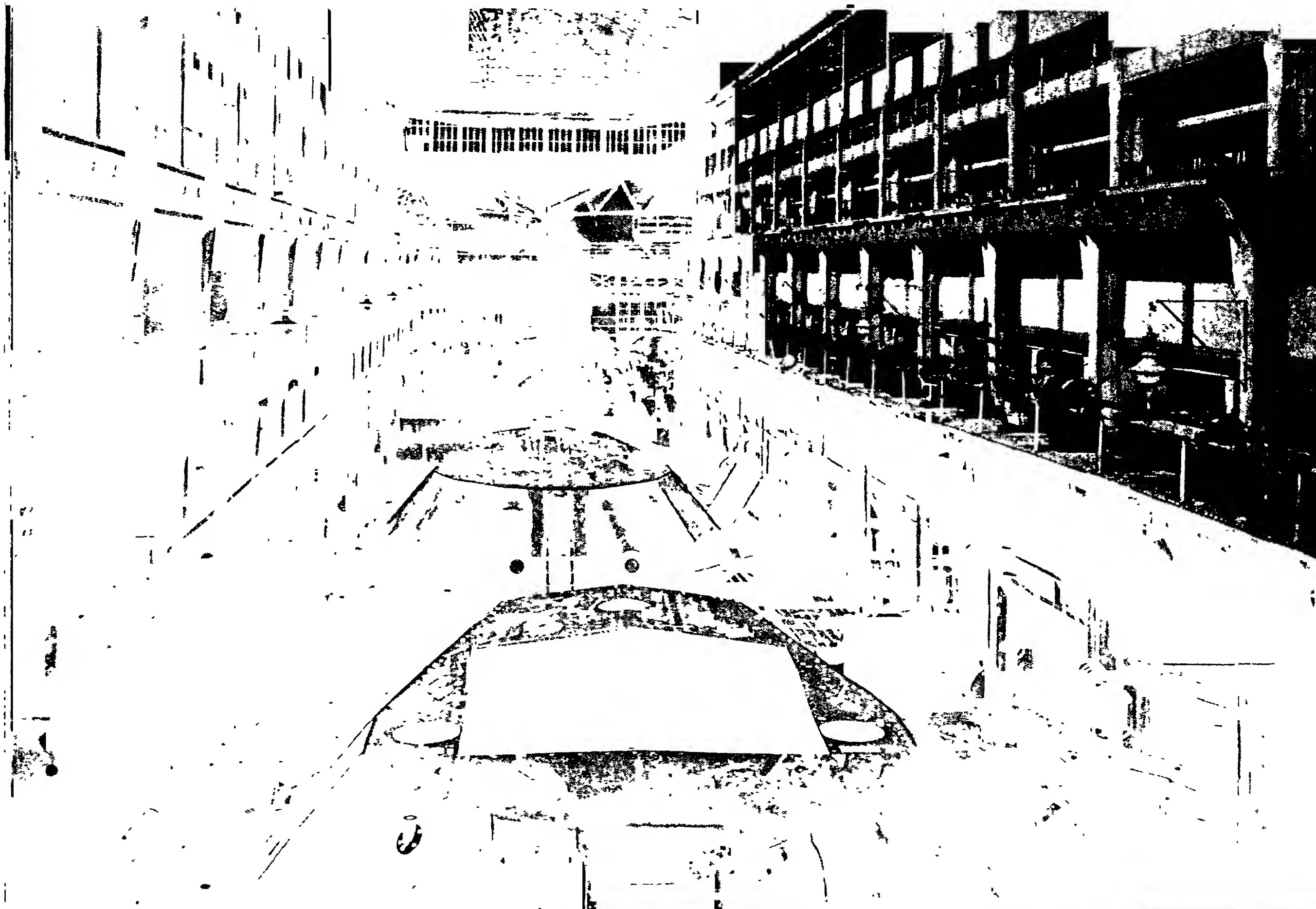
Fusee. In the fusee barrel [**89**] we have another example of a variable leverage, resembling the cams in this respect. But the object in this case is to maintain uniformity derived from variable movements, not only in horological instruments, but in cranes. In the latter, in the jibs of derricks which pass from greater to less radii, and *vice versâ* from the perpendicular, the fusee drum keeps the load at a uniform height.

Tension Organs. The wheel and axle, like its primal mechanical element, occurs in very many forms. The principle [**62**, page 686] is the putting of a rope on or around a large pulley (lever) by which the weight is drawn up on a smaller "axle" (pulley, drum, or lever). This device lends itself to many applications. These form one of the great groups termed by Reuleaux *tension organs*. In other words, they only operate in tension, being useless in compression. They owe a part of their great value to their flexibility, which feature permits of changing the directions of motion. Several materials can be utilised for tension organs, as ropes, chains, wire, and belting in its various forms. In some types of hand hoists, for warehouse work, the form occurs almost absolutely [**90**], the load being lifted by a rope coiled around a small drum, while the endless chain or rope is pulled round the large one. This is also employed in many hand travellers.

The Whip Crane. The whip crane affords another literal example, the load being lifted by a small drum, and the chain or rope pulled round a large one. The slight differences are that the large drum is more correctly described as a double-flanged pulley, and the rope is tied through a hole in one flange and coiled round the pulley by means of a winch on the post below. In hand-travelling cranes operated from below, the rope or chain is fitted around its rim in recesses to "bite" with sufficient gripping power to prevent slip from occurring.

The winch handle of a crane corresponds with the "wheel" in **62**. Its radius is fixed at from 15 to 16 in., because this is as far as a man can conveniently reach. But the diameter of the "axle"—the chain drum or barrel—can be made as small as 6 or 8 in., gaining much power, with corresponding reduction of speed of lift. The smaller the diameter of the drum the greater the mechanical advantage. In practice, this device of altering diameter is often adopted in hoisting machines of less simple character, a set of gears, for example, being retained, and a smaller or larger drum inserted to suit requirements.

But few hoisting machines are so simple as to comprise only the winch handle and drum. The power gained would be totally insufficient for



THE MODERN PALACE OF INDUSTRY: A GUN-MOUNTING SHOP AT THE ARMSTRONG WORKS, ELSWICK

SHOWING TWO 12-INCH TURRETS IN COURSE OF MANUFACTURE

the lifting of heavy loads. In the simple crabs [91], and some small cranes, the first advance on this device occurs. The winch handle is not put on the same shaft as the drum, but on another lying parallel therewith, and the two shafts are "geared" together by means of toothed wheels (levers) of unequal radii, the smaller, actuated by the winch handle, directly actuating the larger on the same axis as the drum. The mechanical gain then is

$$\frac{\text{radius of winch handle} \times \text{radius of wheel}}{\text{radius of pinion} \times \text{radius of drum}}$$

Further, this "simple train" gives place in large cranes to compound trains, in which two or more such combinations exist, and the gain is

$$\frac{\text{radius of winch handle} \times \text{radii of all wheels}}{\text{radii of all pinions} \times \text{radius of drum}}$$

In power-operated cranes, the winch handle is abandoned for the higher pressure agency of steam, water, or that derived from the electric motor. Then, in many cases, trains of gears are diminished in number, or even abandoned in favour of a direct drive.

Pulley Blocks. In the diagrams of certain pulley blocks already given, care was taken to state that the results were secured only by neglecting friction. That was necessary in order to grasp first principles. It is simply an expression of the law that the mechanical work given out by a mechanism would be equal to that put into it, if there were no such thing as friction. But since friction does exist, it happens that every additional element in a machine adds its own quota of friction—more or less severe—to make up a big total, until in one particular case, that of the differential pulley block, substantially 66,* the load will remain suspended in any position. This could not happen in 63 and 64. It happens in 66 solely by reason of the gross total of friction. The mechanical advantage, therefore, in either of these diagrams, is not that of power and weight simply, but of these plus more or less of friction, that of the cords or chains around their pulleys, and of the pulley pins in their bearings. In the application of all the elements now under discussion, the designer strives to lessen friction as far as possible, but in another set he takes advantage of friction and turns it to practical account.

Fig. 92 shows a set of pulley blocks in which the combinations 65 to 67 are embodied in a practical manner by putting the sets of pulleys side by side on the same axis. Any height of lift can be obtained by these by giving enough length of rope. Fig. 93 is a diagram of the differential block, which also embodies the principle of the Chinese windlass. The chain is pulled round the large pulley (A), passing thence to the snatch-block pulley (B) below, thence it returns and winds round the smaller pulley (C). As A and C are cast together [94], the result must be that the snatch-block is lifted by a space equal to the difference in the circumference of A and C. The chain is prevented from slipping by nibs cast in the sheaves, and the friction—due to the different diameters of A and C—equals more than half the power expended, the load therefore remaining suspended without braking. When it has to be lowered, the opposite side of the chain must be pulled on. The lifting rate is, of course, extremely slow.

Inclined Plane. This occurs in the cable ways that play so large a part in the haulage or transport of material. The ropes used are the inclined planes, and the suspended skips or buckets are the loads. Power is applied by ropes, but economy is often studied by making one bucket, or set of buckets, in their descent, serve to draw up another on another incline.

Wedges. The wedge occurs in many forms, in some as a splitting agent, in others as a means of tightening parts. As the first, its best exponents are seen in cutting tools, and if it be objected that these hardly come within the scope of applied mechanics, we must point to the immense importance of the cutting instruments which are embodied in machine tools, and around which these are built. As these will have full treatment in the course on TOOLS, attention is here drawn only to the bare fact.

Cottars. The second group includes cottars and allied forms, which device is employed in many bolts, also in the strap form of connecting rod ends, in effecting rapid union of long lengths of pump rod, of long roof ties, and very much besides. The cottar takes various forms in these examples [95-99].

The cottar pure and simple is driven by a hammer, but in the form of a tail of a bolt [99] it is tightened by screwing the nut. The angle or taper of the wedge is an important detail, not only in cutting tools but in the cottar. If the angle is too large in a driven cottar, the effect of jar on the mechanism will be to loosen it, by causing it to work back out of its seating, hence the set screw in 98. It is therefore made as drawn [95-99]. A cottar bolt may have more taper because the nut holds it against the influence of jar. The value of the cottar in these lies in the provision which it affords of taking up wear in the brasses, to be considered at length in the course on MACHINE DESIGN. Thus we have the function of the cottar as a convenient method of union, and also that of effecting minute compensation for wear.

Keys. The common key [100] is a wedge, cousin-german to the cottar. It secures wheels on their shafts by a wedging action pure and simple, and its taper is but slight, to prevent risk of slackening back. The forms of keys do not concern us here, as they will be dealt with in MACHINE DESIGN, but their relation to the wedge is properly noted.

Keel Blocks. Passing to the massive, we see in the row of keel blocks [101] under a vessel on the stocks a simple means of adjustment. Three wedge pieces, of cast iron, the upper one carrying a piece of teak wood plank, sustain a share of the load of the vessel during construction. By hammering the middle piece farther in or out the height of the block is readily varied, and with it the level of the mighty mass above. The angle is very small,

* Figures before No. 72 have appeared in previous articles.

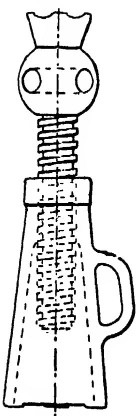
otherwise no effect could be produced, the reason for which was given in connection with **70** [page 688]. Another familiar application of the wedge is to pile driving. The pile, pointed, and having its bottom end shod with steel, is driven by the monkey into sand, clay, and shingle.

Screws. The screw occurs in hundreds of combinations, both as an instrument for gaining mechanical advantage, as a means of fastening, or as a precision instrument, so that one is rather at a loss what examples to select.

One of the most striking yet commonplace examples of the first is the screw-jack, and allied forms, such as the John Bull, the fly-press, the copying-press, pile screw, etc. We call them allied, because, though their functions are dissimilar, their method of action is the same—the exercise of immense force through a very small space, with a small expenditure of power exercised through a large space. One man can, by operating the screw by a lever, lift a load of several tons by the screw-jack [**102**]. A man using the John Bull [**103**], which is a simple screw and lever, can drill holes an inch in diameter in iron and steel. The fly-press [**104**] is essentially a double-ended lever operating a double-threaded screw of quick pitch, for stamping pens, tinned ware, medals, and much besides. The copying-press is an allied form operated similarly. In these elementary machines the gain in power and its compensating loss in speed is obvious. The screw being simply an inclined plane wound round a cylinder, the smaller the angle of the incline the greater the power gained. Therefore, in the screw-jack and the John Bull, the screws are of what is termed fine pitch, or low pitch, or flat pitch. In other words, their angle is low, and consequently the number of turns or threads in a given length is large. But when speed of movement is required, with moderate power, they are of quick pitch, or sloped very much, and the number of turns is less. This is the case in the fly-press [**104**], where momentum is necessary, and that can be obtained only by a screw of rapid traverse, or of considerably more slope than that imparted to the screw-jack. And as a single thread of coarse pitch would cut too deeply into the body, two or three threads are run side by side of the same pitch, which thus results in a stronger body and a larger thread surface to withstand wear.

The Pile Screw. The pile screw is an application of the same kind to the turning of iron piles into the beds of rivers. It is capable of penetrating, not only sand, but gravel, clay, and broken rock. The movement is slow. It is produced, generally, by employing another screw and lever in the form of worm gears, a worm wheel encircling the head of the pile and being turned by a worm, actuated by hand or by an engine.

The propeller embodies segments of a screw of quick pitch. That is, if the screw were completed, the distance between threads would usually be from 18 to 24 ft. Even then the movement of propulsion would be slow, but for the fact that the shaft to which the propeller is attached is driven at a rapid rate, from 60 to 80 revolutions per minute.



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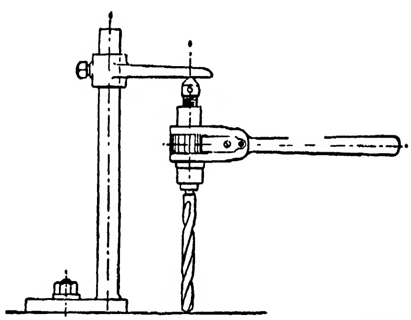

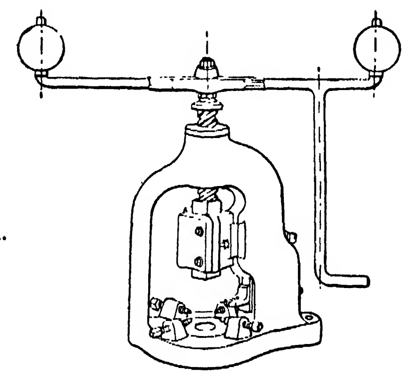

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Conveyor screws have no end-long motion themselves, but they transmit that motion to loose stuff shot into them. Corn, cement, and other pulverised material is compelled by its own inertia to be carried along by the blades of the continuous screw, and at a rate which is controlled by pitch and rate of revolution.

The screw, as a means of measurement, occurs in the lead screws of lathes. It is the first element in cutting screw threads in this machine tool. Though of one unvarying pitch, it controls the cutting of hundreds of other possible pitches by the change wheels—variables introduced between the screw and the mandrel of the lathe. The same element is found in the universal milling machine, in the screws of micrometer calipers, and in the Whitworth measuring machine. We cannot here trace the screw into the numerous worm, spiral, and helical gears, which will be treated in MACHINE DESIGN. The same observation applies to toothed gears and other mechanisms mentioned in these papers, but the design and proportioning of which belong properly to the subject of MACHINE DESIGN.

(continued

Continued from page 691

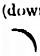
SHORTHAND

Sixth Instalment of the Special Course of Shorthand Taught by Sir Isaac Pitman & Sons on their Twentieth Century Plan

By Sir ISAAC PITMAN AND SONS

IN addition to the general method of doubling consonants already described, eight consonant forms are specially hooked or thickened to express an additional sound.

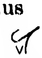
Additional Double Consonants. The following signs represent the double consonants indicated below :

Letters.	*Sign.*	*Name.*	*As in*
KW		kway	*qu*ick, re*qu*est
GW		gway	*gu*ava, an*gu*ish
WL	 (up)	wel	*w*ai*l*, un*well* .
WHL	 (up)	whel	*wh*a*l*e, *whel*p
LR	 (down)	ler	fee*ler*, nai*ler*
RR	 (down)	rer	poo*rer*, sha*rer*
MP, MB		{ emp } { emb }	ca*mp*, e*mb*alm
WH		whay	*wh*ere, *wh*ig

The initial hook in *wl* and *whl* is read FIRST; thus

ill, *will*, *willow*, *whale.*

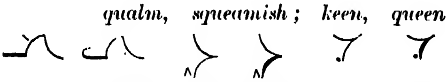
If a vowel precedes *w* or *wh*, write the stroke and not the hook ; thus



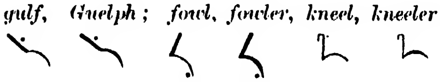
awhile.

The remaining six characters are vocalized like the single consonants ; thus

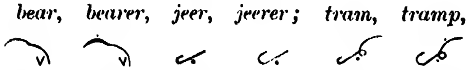
qualm, *squeamish* ; *keen*, *queen* ;



gulf, *Guelph* ; *fowl*, *fowler*, *kneel*, *kneeler* ;



bear, *bearer*, *jeer*, *jeerer* ; *tram*, *tramp*,



mire, *empire* ; *way*, *whey* ; *weasel*, *whistle.*

The double consonants LR and RR are employed only to indicate the terminations *ler* and *rer* ; separate letters must be written when another vowel occurs in the termination, or when a vowel follows ; thus

foiler, *failure* ; *railer*, *raillery* ;

fairer, *furor* ; *usurer*, *orrery.*

The double consonant with a small initial hook becomes *mpr* or *mbr* ; thus

scamp, *scamper*, *clamber*, *limber.*

EXERCISE.

4 

1 Quack, quaker, quince, quiver ; linguist, languoR.
2 Welsh, welfaRe, wool, Willie ; whilst, whalebone.
3 Caviller, ruler, scholar ; adorer, assurer, sneerer.
4 Damp, pomp, Jumbo, Sambo ; whey, anywhere, whipper.

The Aspirate. The aspirate is represented, in addition to the downward and upward , by a downward tick, thus, , (a contraction of the lower half of the sign), and by a dot.

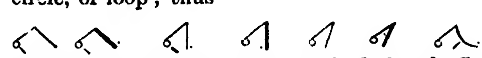
The downward stroke is used when *h* stands ALONE, or is followed by — or — ; thus

high, *Hugh* ;

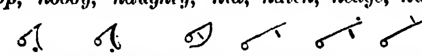
also when it gives a better outline than the upward stroke, as

hawser.

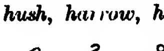
The upward stroke is generally used when *h* is followed by a downstroke, a straight upstroke, the curves *n* and *ng*, or by a hook, circle, or loop ; thus



hop, *hobby*, *haughty*, *hid*, *hatch*, *hedge*, *huffy*,



heath, *heathen*, *hush*, *harrow*, *hero*, *hurry*,



honey, *hung*, *hewn*, *hove*, *hews*, *hackle.*

When following another consonant, the stroke *h* must be so joined that the circle of the character cannot be read as the circle *s*; as

cohere, mohair, Soho; behave, outhouse, unholy.

The downward tick *h* is used initially, and is always read FIRST. It is prefixed to the stroke consonants (the fact that these are the four consonants in the word SMALLER forms a useful mnemonic) or to any of the double consonants to which it will easily join; thus

hiss, hazy, ham, hem, hemp, hall, holly,

hear, hearer, Hebrew, hydra, hedger, hither.

The dot *h* is placed before the vowel which is to be aspirated. It is used as an alternative to the stroke *h*, usually in order to avoid an awkward or long outline; thus

happening, handy,

apprehend, perhaps, manhood, loophole.

Grammalogues. The following grammalogues should be memorized:

had, happy.

EXERCISE.

1

1 Hicks, Hawkins, hackney, huckster, hoop, hitch, heap, heady.
2 Hone, housed, hammer, hardy, unhook, Sahara, abhor, unhitch.
3 Hymn, horn, haze, hasty, Gingham, uphill, household, Redhill.

Upward and Downward L and R. The following rules govern the writing of the consonant *l* in either the upward or the downward direction, and the use of the upward or downward forms of *r*:

INITIAL *L* is generally written upward, thus

loud, aloud, life, alive.

In the following cases it is written *downward.*

(a) When *l* is preceded by a vowel and is followed by a horizontal letter not hooked initially; as

elk, elm, Ellen, almoner.

(b) When *l* precedes and ; as

illusive, lesson, Lessing.

FINAL *L* is generally written upward, thus

Paul, Polly, tale, Italy.

In the following cases it is written *downward.*

(a) After the letters and any straight upstroke, if no vowel follows the *l*; thus

full, vile, scale, quail, sequel,

rail, yell, Howell.

But if a vowel follows, *l* is written upward, as

fully, villa, scaly, Aquila, rally, yellow.

(b) After a straight downstroke if two vowel-signs come between; as

duel, trial.

(c) After a curve and circle, final *l* follows the same direction as the circle; thus

fossil, vessel, thistle,

Kingsley, Cecil, muscle.

(d) After the consonants *n* and *ng*, *l* is also always written *downward;* as

kneel, only, strongly.

(e) The double consonant *lr* is used for the sound of *ler* where a final downward *l* would be written; as

fowler, kneeler, roller.

INITIAL *R* is written upward; thus

rain, rose, ration, rail.

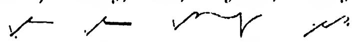
But when *r* is preceded by a vowel it is written *downward*, thus,

air, oar, Arab, argue, arm, arrive,

arraign, arose, oration, early, arena.

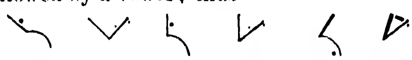
When *r* precedes *t, d, ch, j, th, kl, gl, w*, it is written upward, whether a vowel precedes or not; thus

irritation, aridity, arch, original, orthography,

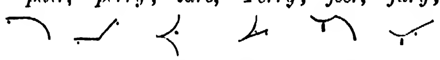


oracle, argal, ornamental, Trevin.

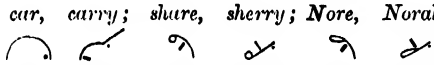
Final *R*, in short words, is written downward when it ends a word, and upward when it is followed by a vowel; thus



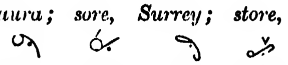
pair, perry; tare, Terry; jeer, jury;



car, carry; share, sherry; Nore, Norah;

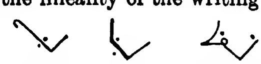


leer, Laura; sore, Surrey; store, story;



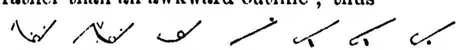
swear, soirée; stern, siren.

When *r* is preceded by two descending strokes, it is generally written upward, so as to preserve the lineality of the writing; thus



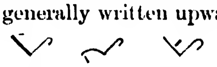
prepare, debar, Shakspere.

Write upward *r*, irrespective of vowels, rather than an awkward outline; thus



officer, reviser, answer, rear, wore, yore, where.

When *r* follows another stroke and is hooked finally, it is generally written upward; thus



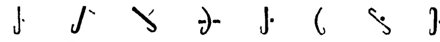
born, morn, portion.

The double consonant *rr* is used for the sound of *rer* where a final downward *r* would be written; thus

adorer, borer.

Key to Exercises in Last Lesson.

1 Pin, Dan, chin, bone, tun, dine, down, twine, tune, brawn, blain.
2 Beef, duff, chief, buff, tiff, dive, Dave, jove, chaff, brief, trough.
3 Roan, rove, won, wove, hen, huff, rife, Rhine, yawn, hone.
4 Vine, thine, main, noon, gain, gave, line, sheen, zone, ocean.
5 Pansy, economy, gainsay, reverse, toughness, profane, tin, tiny.
6 Vain, avenue, deaf, defy, wave, wavy, partial, insinuation.

1 

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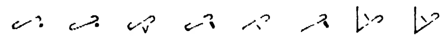
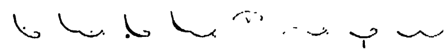
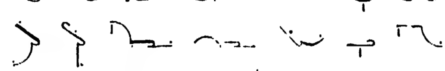
3 

4 

5 

6 

1 Tense, tenses, trounce, trounced, puns, punster, punsters, chains, chances.
2 Cleanse, cleansed, blossom, presume, hansom, lancer, Spencer.
3 Vines, mines, nouns, shrines, doves, gloves, roves, thrones, oceans.
4 Menaces, moans, ominous, assigns, essence, Romans, romance, excellence.

1 

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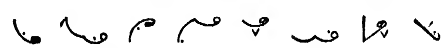
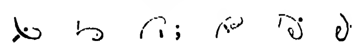
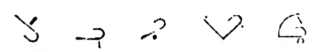
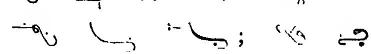
3 

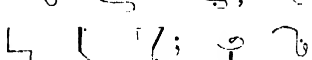
4 

1 Notion, lotion, motion, mansion, delusion, salvation.
2 Potion, portion, operation, reduction, derision, occasion.
3 Fiction, section, Prussian, oppression, expression, tradition.
4 Occupation, reputation, divisional, rational, actionable.
5 Pulsation, sensational, positions, incisions, situation, fruition.

1 

2 

3 

4 

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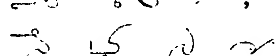
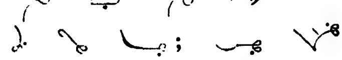
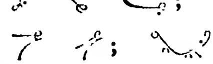
6 

7 

8 

Continued

THE ELEMENTS IN DETAIL

The Elements and their Compounds found in Nature. Hydrogen, Sodium and Soda, Potassium and Gunpowder, Calcium and its Salts

Continued from page 696

By Dr. C. W. SALEEBY

The Elements Found Free. It has already been noted that occasionally the elements occur in the native, free, or uncombined state in Nature. We may make a note of some of these cases.

Oxygen and nitrogen occur in abundance in the atmosphere. Free hydrogen also occurs in very minute quantities. It is somewhat more abundant in the neighbourhood of volcanoes. Iron occurs in the free state in certain meteors, as does the element nickel. Carbon occurs in several forms, as coal and charcoal, derived from the bodies of vegetable organisms long dead. It occurs also as minute crystals, very misleadingly called blacklead, and better named *graphite*, since this form of carbon is used in pencils for writing purposes (Greek, *grapho*, I write). Thirdly, carbon occurs in the form of larger crystals, which we call diamonds. Sulphur, like hydrogen, is found free in the neighbourhood of volcanoes; arsenic, antimony, and bismuth occur in very small quantities in various parts of the world; the very valuable element platinum is found free in tiny particles mixed with the sand of some rivers in Russia and South America. Silver and gold occur free in many parts of the world, as everyone knows. Mercury is sometimes found as such in California, and copper occurs near Lake Superior in North America.

Elements in the Stars. But hitherto we have spoken only of the distribution of the elements on the earth. We must see if these elements occur anywhere else. Are they found in the stars or the sun, and, if so, do they occur in the free state or as compounds? This is one of the most fascinating and important subjects in the whole realm of science, and it will be dealt with in a special chapter at the end of this section. Meanwhile, however, we may briefly note that the elements we know on the earth *are* found, and are found in their free state, in the sun and the stars. In general, we may say that the elements most abundant on the earth are the most abundant in the heavens. A still more remarkable fact is that we are not acquainted with any element in any of the heavenly bodies which is not to be found on the earth. There have been exceptions to this rule, but only temporary ones. For instance, the gas called helium was first discovered in the sun, as its name implies, but it was subsequently found on the earth in the rare mineral cleveite.

Elements Found to be Combined. Nevertheless, by far the greater mass of all the matter with which we are acquainted consists of compounds of the elements, and we must now learn to recognise these compounds by the names given them by chemists. Of course, their number is almost endless, but here we are concerned merely with the principal ones. The compounds of four elements—chlorine, bromine, iodine, and fluorine—have various names, which we shall see later, but those that occur in Nature are called chlorides, bromides, iodides, and fluorides. Of these, the chloride of sodium is common salt, and as the Greek word for salt is *hals*, these four elements are often called the *halogens*—that is, the "*salt makers*." Hence, their compounds may be recognised under the general term of *halides*. Very common also are certain compounds of oxygen and sulphur, which are called oxides and sulphides. The rule is that the termination *ide* is applied to a compound which contains two elements—as, for instance, sodium chloride ($NaCl$), the molecule of which contains one atom of sodium and one of chlorine.

A great many of these compounds are able to combine with each other, forming double compounds, such as the double chloride of magnesium and potassium, or magnesium and sodium. We have learnt that nearly all the salts of sea-water exist in this complex state of loose union.

Acids, Bases, and Salts. We have said that the compounds of oxygen are called oxides, but this term is only applied to one half, so to speak, of the compounds of oxygen—those which we have already called *bases*. A special name is given to the double oxides of hydrogen and the non-metals. These are called acids; for instance, sulphuric acid, H_2SO_4 is, as the formula shows, a double oxide of hydrogen and sulphur, which is a non-metal. On the other hand, caustic soda, $NaOH$, as the formula shows, is a double oxide of hydrogen and a metal. These last we call *hydroxides*. Thus the technical name for soda is *sodium hydroxide*. In the case of the acids, for convenience, we make a point of writing the hydrogen first in the formula, so as to indicate that they are acids.

Now, when these two kinds of oxides—*viz.*, the acids and the hydroxides—are mixed with one another, there frequently occurs a rearrangement of their elements, which is called a double decomposition. For instance, when sulphuric acid and soda are mixed, the metal of the hydroxide displaces the hydrogen of the acid; thus, instead of H_2SO_4, we get Na_2SO_4; whilst the displaced hydrogen unites with the oxygen which is left over, to form water. The name given to the double oxide now formed, sodium sulphate, which is a double oxide of a metal and a non-metal, is a *salt*. We have already seen that this term salt is also applied to the halides, such as common salt or sodium chloride.

Preparation of Elements. Given, then, that we have a number of compounds of the elements, and that we wish to obtain the pure elements from them, how are we to proceed? There are three possible methods of breaking up the compound and obtaining the element desired.

In the first place, we may break up the compound by electricity. This is possible only when the compound can be dissolved or melted, and when it is a substance which conducts electricity. If these conditions are satisfied, we may pass an electric current through the compound, and may obtain the freed elements by this means. The simplest and most important instance of the employment of this method is the passage of an electric current through water, which is decomposed and provides us with free hydrogen and free oxygen. In other words, the electricity splits the water up into two invisible and colourless gases which have not the smallest resemblance to it. This process of passing electricity through a liquid, by means of which the liquid or some substance contained in it undergoes decomposition, is known as electrolysis; it need not further be discussed here, as it is dealt with in ELECTRICITY.

Other elements that may be prepared by means of this method are sodium and potassium, barium, calcium and strontium, copper, silver, gold and fluorine.

This principle is of very great practical importance, since it is the essential one of electroplating and electrotyping, each of which is separately discussed in the SELF EDUCATOR.

The Compounds and Heat. But, *in the second place,* a compound may also be resolved into its constituent elements by heat. It is believed that when the temperature is sufficiently high, no compounds can exist, but though this method is thus theoretically applicable to all cases, there are not very many instances in which it is of practical use. One or two may be noted. The very useful element sulphur frequently occurs in union with iron, as what is called *iron pyrites.* When this is heated (say, for instance, in a hard glass tube) some of the sulphur is given off, and can be immediately seen, since it produces a yellow coating upon the glass.

The preparation of oxygen by this method is of historic interest. Priestley discovered oxygen, as we saw in our introductory chapter, by this method. He applied heat to the red oxide of mercury (HgO), and thus decomposed it, driving off free oxygen, which he was able to collect after passing it through water. Very shortly afterwards the Swedish chemist Scheele obtained oxygen by heating another of its compounds, the oxide of manganese, which has the formula MnO_2.

But by far the most common method of preparing the free elements is, *in the third place,* by displacing them from their compounds by means of their action on another element. The displacing elements usually employed are sodium, which turns out magnesium and aluminium from their compounds with the halogens; hydrogen, which turns out a number of elements, such as iron, tin, lead, arsenic, etc.; and carbon, which is really the most important of all, since, to begin with, it turns out the hydrogen and sodium themselves, and thus enables us to use them for turning out other elements. Carbon also turns out potassium, zinc, tin, lead, phosphorus, arsenic, bismuth, etc.

The Groups of Elements in Detail. We must now proceed to consider the groups of the elements in detail. The first group we will take consists of hydrogen, sodium, and potassium.

Hydrogen (literally the "water-maker," since it is one of the constituents of water) has been recognised as an element ever since the work of the great Cavendish, already referred to. It occurs on the earth to a small extent in a free state, and to a very large extent as a compound, as we have already noted. It is present in vast quantities in the stars, and the sun is completely surrounded by an atmosphere of hydrogen. Many of the stars are so eminently characterised by the amount of hydrogen they contain that they are generally described as the hydrogen stars. A typical example of such a hydrogen star is the most brilliant star in the whole heavens, Sirius, or the Dog-star.

The preparation of hydrogen is most commonly effected by the action of metals upon acids. We have already seen that an acid always contains hydrogen*, and we can obtain the hydrogen by itself if we turn it out from the acid by means of a metal which takes its place. The usual substances employed are sulphuric acid (H_2SO_4) and zinc. The reaction is represented by the formula

$$H_2SO_4 + Zn = ZnSO_4 + H_2.$$

When it is desired to obtain hydrogen in much larger quantities the element may be obtained from water by the interaction of red-hot iron and steam or by the action of steam—that is to say, gaseous water—on red-hot coke. The coke, which is carbon, takes the oxygen from the water, leaving the free hydrogen. When prepared by this method the gas is impure, since it is mixed with a certain amount of a compound of carbon and oxygen.

Properties of Hydrogen. Hydrogen is a colourless, odourless, tasteless gas, the lightest of all known substances. (It is understood, of course, that the ether of the physicists, not to be confused with ether, the chemical compound, is excepted when we make this statement.) Of all the known kinds of what the chemist calls matter, hydrogen is the lightest. We have already seen that on this account the weight of this element has been taken as the unit for comparison with the weights of other elements. The weight of hydrogen is less than $\frac{1}{11000}$th that of water, and its density is about ·07 that of air. Hence it may be poured upwards from one jar to another. So light is

* The reader must not be confused by carbonic acid, CO_2. This is really an acid without its water—an *anhydride.* Its full formula would be H_2CO_3. (Compare potassium carbonate, K_2CO_3.)

hydrogen that light vessels filled with it will rise in air. The first balloons were filled, not with hydrogen, but merely with hot air. Of course, as soon as the air cooled, the balloons descended, but balloons are now filled with hydrogen, and can float for an indefinite period.

The gas is only very slightly soluble in water, the universal solvent, which is capable of dissolving at least some quantity of nearly all substances. One hundred volumes of water will absorb about two volumes of hydrogen. The gas may be breathed without causing any deleterious effects, but it is incapable of supporting life, nor will it support combustion.

Liquid and Solid Hydrogen. Until recent years hydrogen had never been converted into a liquid, still less into a solid, but both these feats have lately been accomplished by Sir James Dewar, the famous professor of chemistry at the Royal Institution, London. Liquid hydrogen presents no striking appearance. It is by far the coldest liquid that can be obtained. When it is rapidly evaporated under certain conditions its temperature is still further reduced, so that a small quantity of solid hydrogen is formed; this frozen hydrogen represents the lowest temperature yet attained by the chemist. It is probably about 260° below the freezing-point of water. This is reckoned on the Centigrade scale, in which the freezing-point of water is zero, so we may say that the temperature of solid hydrogen is about $-260°$ C. The recent ability to liquefy hydrogen has been of great use in the study of low temperature chemistry, since by its means very low temperatures can be conveniently obtained and maintained.

Certain substances such as carbon and many metals have the power of absorbing hydrogen in a very extraordinary fashion. The rare metal palladium, for instance, absorbs about 900 times its own volume of hydrogen. We cannot doubt that this is more than a merely physical action; there must be some sort of chemical combination. The hydrogen taken up in this form by a metal is known as *occluded hydrogen*. When the metal is heated the gas is given off again. Iron, similarly, has the power of occluding hydrogen, and thus the gas is sometimes found in the iron that has reached the earth in meteors or shooting stars.

Hydrogen and the Halogens. Reference has already been made to the group of substances known as the halogens—chlorine, bromine, iodine, and fluorine. Each of these substances unites with hydrogen to form an acid. Of these the most important is hydrochloric acid (HCl). The most important compound of hydrogen, of course, is water, which is really the oxide of hydrogen (H_2O). When the two gases hydrogen and oxygen are mixed in the form of jets and ignited, they unite, producing a very intense heat. This oxyhydrogen jet is largely used for raising the temperature of lime, thus producing a brilliant light known as limelight.

If we compare a simple acid, such as hydrochloric acid (HCl), with a salt of that acid, such as sodium chloride or common salt (NaCl), we see that there is a certain resemblance in chemical behaviour between hydrogen and a metal. In general we may say that an acid differs from a salt in that the hydrogen of the first replaces the metal of the second.

Thus it was for long thought that hydrogen was really a metal, and that if we could obtain it in a solid form it would have metallic characters, but now that hydrogen has been solidified this view has to be abandoned.

Sodium. This exceedingly important element has a very wide distribution in Nature; it is a constituent of common salt, it is a necessary constituent of all or nearly all living tissues, and it occurs in enormous quantities in the form of many other salts found in the soil and in minerals. Finally, it is abundant in the sun and in the stars. Sodium, when heated, yields a brilliant yellow light which is very characteristic. It is so universally present that in practical chemistry there is no little difficulty in getting rid of all traces of it. It is nowhere found free or uncombined on the earth, though, no doubt, it exists in the free state in the sun and stars. The symbol for sodium is Na, and its atomic weight is about 23. This element was discovered by Sir Humphry Davy in 1807. Davy was one of the greatest of English chemists; he invented the safety-lamp and discovered laughing-gas; he was connected with the Royal Institution of London, and the now famous laboratory in Albemarle Street, where Sir James Dewar has made so many great discoveries, is known, after Davy and Michael Faraday, as the Davy-Faraday Laboratory.

Davy obtained sodium by passing a very powerful current of electricity through the hydrate of sodium (NaOH), previously fused or melted. The metal is now prepared in a different manner, by heating a mixture of carbonate of sodium and charcoal.

Characters of Metallic Sodium. When the metal is obtained, it is found to be of a silver-white colour and very soft, so that it can be readily cut with a knife. It is exceedingly light, and floats on water. It has an intense affinity for oxygen, which it immediately takes from water. Thus, when sodium is thrown on to water decomposition occurs, and evolves free hydrogen, which immediately burns in combination with the oxygen of the air. When sodium is exposed to air, the surface rapidly tarnishes, owing to the formation of a film of oxide of sodium. This oxide of sodium is formed when sodium is thrown upon water, but it also combines with some more of the water that is present, forming the substance known as caustic soda, or sodium hydrate, which has the formula NaOH. The equation represented in this decomposition runs as follows: $2H_2O + Na_2 = 2NaOH + H_2$. Caustic soda is an important substance which has very powerful alkaline properties. It is called caustic because of its action on the skin. Sticks of solid caustic soda have a very powerful solvent action on the skin, and were formerly used to remove warts.

When the oxide, or the hydrate of sodium meets with carbonic acid (CO_2) it forms a compound known as carbonate of sodium, which has the formula Na_2CO_3. As this usually occurs, however, in its crystalline form, there is combined with it a quantity of water. Water which thus combines with salts in the formation of crystals is known to the chemist as water of crystallisation. The number of molecules of water that combine with one molecule of carbonate of sodium is 10, so the formula of the substance in its crystalline form will read Na_2Co_3, 10 H_2O. On exposure to air, however, the water tends to leave the crystals, which break down a· l fall into powder. This tendency to lose their water of crystallisation is a general characteristic of the salts of sodium. The property is known as efflorescence, the opposite of which is deliquescence.

"Washing" and "Baking" Soda. Carbonate of sodium, known to the housewife as "washing soda," is found in Nature to a small degree in soda lakes, in the water of some geysers, and also in the soil. It used to be obtained in considerable quantities from certain marine plants. These were burnt, their ashes were treated with water, the solution thus obtained was evaporated, and yielded a very impure form of sodium carbonate, or soda, which was known as *barilla*. This was largely used in the making of soap. The process has now, however, fallen almost completely into disuse, since the salt can now be prepared much more satisfactorily by other means. Of these the first is known as the Leblanc process, and the second as the ammonia process.

The bicarbonate of soda, or baking soda, differs from the last in that it contains twice as much carbonic acid in proportion to the sodium. Its formula is $NaHCO_3$. It is a white powder somewhat less soluble in water than washing soda; it is largely used in medicine, as a non-irritant alkali.

Borax. Several other salts of sodium are important. The borate, for instance, is known as *borax*. Its full chemical name is biborate of sodium, and it occurs in large quantities in Borax Lake, California. It used also to be obtained from lakes in Tibet. It may also be prepared by the union of carbonate of soda and boracic acid. It is used in medicine, in glass-making, as an enamel, and for other technical purposes. It usually occurs in the form of prismatic crystals which, like those of carbonate of soda, have 10 molecules of water of crystallisation.

The nitrate of sodium ($NaNO_3$) is often known as "Chili saltpetre," or sometimes as cubic saltpetre, since its crystals are very nearly cubical. It occurs in the soil in various parts of South America. Like ordinary saltpetre—soon to be discussed—it is used in making nitric acid.

The silicate of sodium, known as "soluble glass," is soluble in water; it is used for fire-proofing. The phosphate is a constant constituent of the animal body and a necessary ingredient of the food.

Potassium. Potassium is an important metal, which has many resemblances to sodium. Its symbol is K, and its atomic weight is 39; it was discovered by Davy at the same time as the discovery of sodium, and in the same way—by passing electricity through fused potash. Potassium is abundant in Nature, but, like sodium, is never found in the elemental state. It occurs in all living tissues, and when plants are burnt, it remains in the ash, hence the name potash, or potashes. It is an important ingredient of seawater, and occurs abundantly in the form of its nitrate in the soil of certain parts of South America.

Preparation of Potassium. Potassium is now prepared in similar fashion to sodium, by means of the interaction of charcoal and the carbonate of potassium. The charcoal (which is simply carbon) and the carbon in the carbonate unite with the oxygen of the carbonate to form a poisonous gas, *carbonic oxide* (CO), leaving the potassium behind in the form of a gas, which solidifies inside a flattened box of metal that receives it. There is some danger in the manufacture. The decomposition is represented by the formula $K_2CO_3 + C_2 = K_2 + 3CO$. (Potassium carbonate plus charcoal = Potassium plus carbonic oxide).

Thus prepared, the element is found to be a whitish metal which strongly resembles metallic sodium. It floats on water, which it decomposes in a similar fashion to that of sodium. When sufficiently heated—and the same applies to any salt of potassium—it yields an exceedingly beautiful violet colour, which contrasts markedly with the brilliant yellow colour yielded by sodium. Like sodium, potassium forms certain oxides or compounds with oxygen, but these are of no practical importance.

Caustic Potash. Potash is of great importance. It is otherwise known as caustic potash, potassium hydrate, or potassium hydroxide. Its formula is KOH—which may be compared with the formula of water HOH—usually written for convenience H_2O. When we institute this comparison, we see that the difference between potash and water is that one-half of the hydrogen of the latter has been replaced by potassium. (A similar statement is true of caustic soda.) Potash is formed by the action of potassium on water. It is prepared for practical purposes by a process similar to the Leblanc soda process. The potassium is obtained from potassium chloride, which occurs in enormous quantities at Stassfurt. This yields potassium carbonate, and from the latter, by its interaction with slaked lime (solutions of the two being boiled), there is obtained caustic potash KOH. This is usually cast in the form of sticks. It is a very powerful caustic, very similar in properties to caustic soda. It has great affinities for water and carbonic acid, and is very largely used as a reagent in chemistry.

As we have seen, the ashes obtained from burnt plants were called potashes. The carbonate of potash, now prepared as we saw in the last paragraph, may still be obtained by burning wood, in places where wood is cheap and abundant. The plant does not manufacture its potassium carbonate, but it takes it ready-made

from the soil. It is a necessary ingredient of all soils in which plants are to grow, and, if deficient, must be added in the form of a manure. The purer form of potashes, obtained by recrystallising the crude product, was called *pearl-ash.* Carbonate of potassium is largely employed in chemical research, in various industries, in glass-making, and also in the making of soap. All soft-soaps contain potassium.

Reference has already been made to chloride of potassium, a white, crystalline, easily soluble salt, usually obtained from Stassfurt.

Chlorate of Potassium. The closely allied salt known as the chlorate of potassium, $KClO_3$, is of considerable importance because of its large superfluity of oxygen, which it is very ready to give up to any substance that will take it. So ready is it that when mixed with sulphur and charcoal it forms an explosive mixture. It is an ingredient of certain kinds of matches, and it is largely used in medicine as a safe and powerful antiseptic, which it is in virtue of its ability to give off nascent oxygen. In simple ulceration of the mouth no other remedy is so valuable as chlorate of potash.

The iodide, KI, and the bromide, KBr, are of no great chemical importance, but they are amongst the most valuable of all drugs. The sulphate, K_2SO_4, is occasionally used in medicine. The two salts containing chromium—the chromate and bichromate—are also used in dyeing, in chemical research, in photography, and the latter occasionally in medicine. The cyanide, KCN, owes all its properties to the fact that it is practically equivalent to hydrocyanic, or prussic acid. It is a whitish salt used in photography, in chemistry, in electroplating, and very occasionally in medicine.

Saltpetre. The nitrate of potassium, KNO_3, is usually known as nitre, or saltpetre, the latter name being a modern version of the alchemists' name for it, which was *sal petræ*, or *salt of rock.* It occurs in the soil, as already stated, being formed by a highly complicated and interesting process into which bacteria enter. [See BACTERIOLOGY.] These bacteria form nitric acid in the soil by a union of the nitrogen in organic substances derived from the bodies of animals and plants with the oxygen of the air, the process being known as *nitrification.* The nitric acid combines with the potash salts present in the soil to form potassium nitrate, or saltpetre. Sometimes this method is employed for the preparation of saltpetre, but, as a rule, the salt is prepared by the interaction of potassium chloride and Chili saltpetre, or sodium nitrate. When strong solutions of the two are heated together, a double decomposition occurs, the potassium and sodium changing places. Common salt, or chloride of sodium, is precipitated or solidified in the solution, whilst saltpetre remains in it, and can thus be separated. The salt forms clear crystals, usually prismatic. It is very readily soluble in water. At high temperatures water will dissolve much more than its own weight of saltpetre.

The salt is still used in medicine, being sometimes given internally, and sometimes burnt in a saucer, when it yields fumes which often relieve attacks of asthma. It is much used in the making of fireworks and fuses, and also in ordinary chemical processes. It is a most important ingredient of ordinary gunpowder, of which, indeed, it forms about three-fourths.

Gunpowder. Gunpowder is really a mixture of saltpetre, charcoal, and sulphur, all the ingredients being mixed in the form of a granular powder. Nitre has to be used rather than sodium nitrate, for this salt, contrary to the usual rule of sodium salts, has an affinity for water, and thus the powder made with it cannot be kept dry. It is said that gunpowder was invented in the eighth century. The value of the mixture depends upon the fact that when it is fired the saltpetre gives up its oxygen very rapidly to the charcoal and sulphur. The results of the oxidation of these latter are gaseous, and the nitrogen of the saltpetre is also given off in gaseous form. The smoke which is produced serves no practical purpose; it consists of various solid salts, such as sulphide of potassium. Owing to the fact that a very high temperature is produced, the gases which are evolved demand a large amount of space—about 2,500 times as much as the space occupied by the powder. It is the sudden and imperative expansion of these gases rapidly produced at such a high temperature that gives gunpowder its explosive property.

Alkaline Earths. The next group of elements which we may discuss consists of *calcium, barium,* and *strontium.* In their elemental form these do not occur in Nature, and they can be obtained in this form only with much difficulty. When a powerful electric current is passed through the chlorides of these metals in a melted state they can be obtained, but they are very unstable, having intense affinities both for oxygen and water. If only the first be supplied to them they immediately form oxides, but if water be present, they form hydroxides, or hydrates. These three elements are usually known as the *alkaline earths.*

Calcium is a very widely diffused element. It is a necessary ingredient of the living body, especially of the bones. It occurs in the sun and stars in considerable quantities. The other forms in which it occurs on the earth will be named when its various salts are discussed. Of these salts the most important is the carbonate, which has the formula $CaCO_3$. It is one of the most widely distributed of all minerals. It occurs in the forms of limestone, marble, chalk, and coral. Chalk consists of the calcium carbonate remains of the bodies of countless myriads of minute creatures that once lived in the sea. These have left a sort of "shells" behind them. The structure of the shells can often be detected with a microscope. But calcium carbonate also occurs in a very large number of crystalline forms, such as calc-spar, or Iceland spar, also the mineral known as aragonite, and in many other forms. Crystalline calcium carbonate, when pure, is colourless, but very frequently it contains various impurities, such as salts of iron, which give it various tints.

The term oolite is applied to the form of calcium carbonate which occurs as minute rounded grains which, like chalk, are of organic origin. Sometimes it is known from its appearance as roe-stone. This structure is so common in a certain level of English rocks that they are known to geologists as the oolites. [See MATERIALS AND STRUCTURES.]

Changes in Rocks. Under certain conditions the carbonate of lime, or calcium, is constantly liable to undergo a very important change, which plays a great part in geology, for it conditions a number of the slow but incessant changes which determine the form of the earth's surface. The process is simple to understand. On the earth are rocks containing carbonate of lime, much of which acts as a sort of cement, holding rocks together. In the air is a quantity of carbonic acid, CO_2. As rain falls it absorbs some of the acid. The rocks are thus constantly exposed to the action of carbonic acid in solution, and this produces a very important change. Carbonate of lime is converted into bicarbonate—sometimes called acid carbonate. When a salt contains twice the usual amount of the acid constituent—which in this case is carbonic acid—its character may be indicated by using the prefix *bi*, from the Latin *bis*, twice; or it may be described as an acid salt, in order to indicate that it contains a certain amount of acid, which, so to speak, is "to spare." There is this great distinction between the carbonate and the bicarbonate—that, whilst the first is quite insoluble in water, the second is readily soluble; hence the supporting structure of the rocks is broken down, and they are washed away, as sand or clay, to form what are called alluvial plains. Thus mountain ranges are slowly crumbled away.

Stalactites and Stalagmites. Another important change produced in a similar way consists in the formation of what are called stalactites and stalagmites. The first consist of long crystals of carbonate of lime, which hang down in very striking fashion from the roofs of limestone caves, looking very much like icicles. They occur along the lines where there are cracks or joins in the roof of the cave—that is to say, along the lines where water from above drips through. As the drops fall upon the floor of the cave the process which resulted in the formation of the stalactite continues, and there is built up from the floor a sort of pinnacle which is known as a stalagmite, and which grows up to meet a stalactite growing from above. Often they join, forming pillars of indefinite thickness. Now, how does this process occur?

The water that percolates through the roof of the cave brings with it a quantity of carbonic acid derived from the air, and is thus enabled to dissolve some of the carbonate of lime from the rock through which it passes, with the formation of bicarbonate. But when the drop reaches the surface of the roof of the cave, and begins slowly to evaporate, the extra carbonic acid in the bicarbonate can no longer be retained. In other words the bicarbonate undergoes decomposition, yielding the insoluble carbonate, which is immediately deposited. A similar process occurs when the drop reaches the floor. The action may be represented by the formula

$$H_2Ca(CO_3)_2 = H_2O + CO_2 + CaCO_3.$$

Attempts have been made to estimate the age of caves by means of the size of the stalactites and stalagmites which they contain, but these are highly unsatisfactory. Needless to say, stalagmites do not occur except when the floor of the cave is sufficiently level.

Hard and Soft Water. The difference between hard and soft water depends entirely upon the fact that the former contains more than a certain quantity of bicarbonate of lime in solution, whereas the soft water contains very little, or none. Two kinds of hardness are distinguished in water, one which depends on the presence of the sulphate of calcium, and is called permanent, while the other depends upon the presence of bicarbonate of calcium, and is called temporary. It is this alone that concerns us here. The adjectives are applied to indicate the fact that, in the latter case, the hardness can be removed with comparative ease. Perhaps the simplest way of removing it is by boiling the water, which decomposes the bicarbonate exactly according to the equation given above to explain the formation of stalactites. Another way of getting the bicarbonate of lime out of the water is by adding more lime to it. The lime that is to be added is usually known as milk-of-lime; chemically it is called calcium hydroxide, and its formula is $Ca(OH)_2$.

How to Soften Water. This substance is only very slightly soluble in water, but when it is partly dissolved and partly suspended in water it forms the opaque white fluid which is called milk-of-lime. Now, when this is added to water containing the bicarbonate, the milk-of-lime takes from the bicarbonate its extra share of carbonic acid, which it combines with itself to form carbonate of lime, and this same salt is also formed from the bicarbonate when it has lost its extra carbonic acid. If the water is now filtered or is allowed to stand, the insoluble calcium carbonate is disposed of, and so the water is made soft. The following formula represents the decomposition:

$$H_2Ca(CO_3)_2 + Ca(OH)_2 = 2CaCO_3 + 2H_2O.$$

(Calcium bicarbonate plus calcium hydrate = Calcium carbonate plus water.)

Calcium carbonate may further be used to illustrate some other simple chemical changes. For instance, if limestone consisting of this salt be raised to a very high temperature, it undergoes a decomposition according to the formula

$$CaCO_3 = CaO + CO_2.$$

The carbonic acid is driven off, and there is left behind the oxide of lime, CaO, or *quicklime*. This quicklime has an exceedingly strong affinity for water. When this thirst is slaked by the addition of water, the oxide of lime is converted into the hydrate, or hydroxide of lime mentioned above, which is commonly known as *slaked lime*. The difference between these two last substances is typical of the difference between an oxide, and a hydrate or hydroxide.

Continued

POETRY OF THE ELIZABETHAN AGE

2. The Dramatic Poets—continued. Dealing with Ben Jonson, Beaumont and Fletcher & Shakespeare's Contemporaries, & concluding the Study of this Period

By J. A. HAMMERTON

Ben Jonson. The greatness of Shakespeare could not be better illustrated than by contrast with the character of BEN JONSON (b. 1573; d.1637). In almost any age Jonson would have been accounted a writer of the most extraordinary parts. His scholarship was profound—indeed, Shakespeare's learning is, by comparison, almost superficial—but in all his serious efforts to produce a dramatic work of the highest he gives evidence of scholarship only, and not of that divine, ineffable "something" which makes the poetry of Shakespeare as harmonious a part of the world's intellectual life as seed-time or harvest is of its physical life. It is hard to determine how Jonson came by his learning, as we have evidence of only a few weeks spent at St. John's College, Cambridge, in his sixteenth year, after leaving Westminster School. In his youth he had to work for a time, to his never-forgotten disgust, at bricklaying, and he was a soldier in the Low Countries when only eighteen years of age. It has been asserted that at nineteen he returned to Cambridge and completed his studies, but this theory rests rather on the desire to explain his wonderful knowledge of the Latin poets than on any direct evidence. He was as injudicious as his great contemporary in contracting an early marriage, and perhaps poverty, as much as inclination, led him to become an actor, in which profession he excelled no more than Shakespeare did.

Influence of Classical Models. Steeped in the works of the pagan poets, his native genius was undoubtedly more lyrical than dramatic in inspiration, though he gives evidence of a certain saturnine temper which, inclining to tragedy, but modified by the former impulse, expresses itself in satire. It was with a comedy, however, that he first essayed to win success on the stage, and "Every Man in His Humour," produced in 1596, and performed two years later by the company of which Shakespeare was a member, had a considerable success, which led to his following it with "Every Man out of His Humour." Both are admirable comedies, and, like his two tragedies, "Sejanus" and "Catiline," follow classical models; but the author is so obviously subjected to the strict rules of classical composition that his work lacks spontaneity and natural grace in the comedies and tenderness in the tragedies. This is the fault of all his plays: they are overlaid with the weight of his learning; made coldly accurate by the careful observance of his models; and neither in tragedy nor in comedy does he sound the depths of human emotions. Though the character is always perfectly observed and represented, he does not take us to the hidden springs, as Shakespeare does, not so much by art as by intuition, even in his lesser works. For these reasons Jonson's dramatic works earned small popularity in his time, and have ever since been dead to all but students of literature. "Every Man in His Humour" has occasionally been revived on the stage, but never with lasting success.

The Masque. Such prosperity as Jonson enjoyed came from the composition of masques, which, in his time, were a favourite amusement of the Court and the aristocracy. The masque is a form of stage entertainment midway between a pageant and a play. It may be said to have been originated by the introduction into royal processions of masked, or disguised, persons representing allegorical or fictitious characters. This developed into entertainments resembling the tableaux vivants, still popular in our own time, in which Henry VIII. is known to have delighted. Under Elizabeth the masque rose into extreme popularity, and most of the dramatists, with the notable exception of Shakespeare, set themselves to supply their lordly patrons with such entertainments. They were written both in prose and verse, the dialogue being interspersed with songs, and afforded opportunities for the display of gorgeous costumes and scenic decoration quite foreign to the stage of the time, where no attempt was made at scenic effect or accuracy of "make-up." Ladies also took part in these private theatricals, whereas on the stage all the feminine parts were discharged by boys or young men. The finest example of this class of poetic composition is Milton's "Comus," written for the Earl of Bridgwater, and acted at his residence, Castle Ludlow, in Shropshire, on Michaelmas Night, 1634, in which the masque as an acted entertainment may be said to have culminated, for it died out under the Commonwealth and has never been revived.

Jonson's Lyric Poetry. Some of the best specimens of Jonson's verse are to be found in his masques, but his exquisite little song, "Drink to me only with thine eyes," is one of fifteen lyrics in a collection entitled "The Forest," published in 1616. Jonson, in his personal character, had some traits which suggest likeness with his great namesake of the eighteenth century, and "rare Ben" anticipated Samuel's satirical treatment of the Scots, as he came near to having his ears clipped for making fun of King James's countrymen in "Eastward Ho," a drama in which he collaborated—a rare thing for him, as he was vain of personal achievement—with Chapman, Marston, and Martin. He died 6th August, 1637, having experienced loss of friends and favour in his later years. His

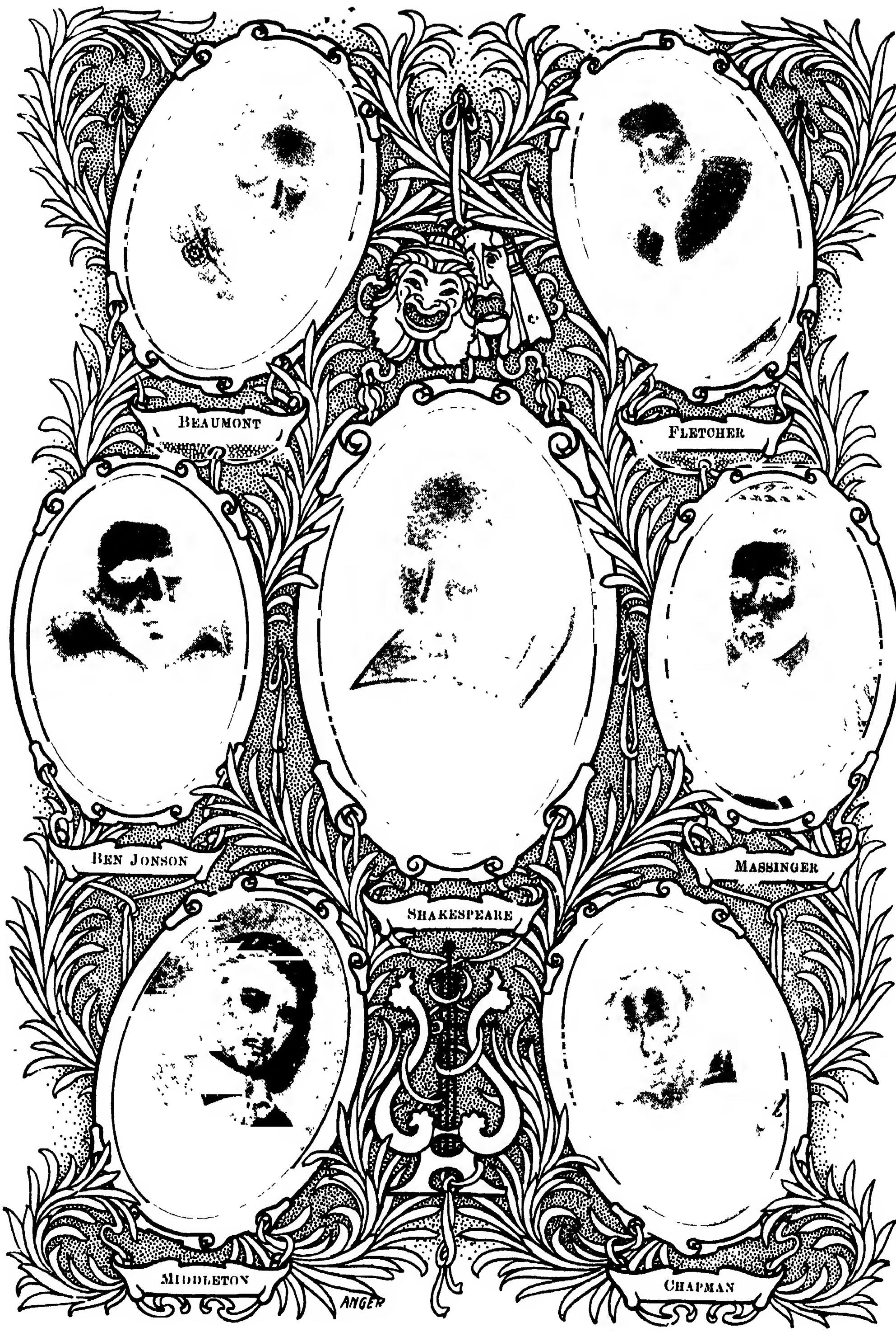
gravestone, in Westminster Abbey, is inscribed, "O Rare Ben Jonson." On the whole, every reader with any pretension to knowledge of our literature must make some first-hand acquaintance with the works of Ben Jonson. Specimens of his lyric poetry are to be found in most collections, and several anthologies are devoted to it entirely, while some of his best plays have also been reprinted in recent years.

Beaumont and Fletcher. Reference has been made to Jonson's collaborating with other dramatists. This was a favourite method of work among the Elizabethans, as it is in our own time with the French dramatic writers. But the most noteworthy example of collaboration was furnished by Beaumont and Fletcher, who were so intimately associated in their lives that they had house and clothes in common. Both were of gentle birth, scholars, and men of genius. Their plays — chiefly comedies — were even more popular than Shakespeare's, being, if anything, more in harmony with the temper of the period. FRANCIS BEAUMONT (b. 1584; d. 1616) probably became acquainted with his friend JOHN FLETCHER (b. 1579; d. 1625) at the meetings of the celebrated Mermaid Tavern, frequented by Shakespeare, Jonson, and the wits of the time, as celebrated by Beaumont in his verses to Jonson:

"What things have we seen
Done at the Mermaid! heard words that have been
So nimble, and so full of subtle flame,
As if that every one from whence they came
Had meant to put his whole wit in a jest,
And had resolved to live a fool the rest
Of his dull life."

Characteristics of their Work. The dramatic writings of this celebrated pair are full of fancy and bright pictures, though there is no denying their "studious indecency," in which they reflect, more racily than need be, the manners of their age. Fletcher had probably the greater share in the composition of the plays which bear their joint names, and alone he wrote at least twenty, Shakespeare being thought to have collaborated with him in "The Two Noble Kinsmen," while Fletcher had a hand with Shakespeare in the writing of "Henry VIII." It is hard to differentiate between Beaumont and Fletcher, though it seems easy enough by comparing their individual and their joint productions; but perhaps it is not wrong to say that the one had a more strongly marked lyrical gift, while the other was essentially dramatic in his inspiration. Both men were immensely popular with their contemporaries, and theirs will ever remain among the great names of Elizabethan drama. By way of summing up their characteristics, we cannot do better than quote this comparison from the poet Campbell's "Specimens of the British Poets": "There are such extremes of grossness and magnificence in their dramas, so much sweetness and beauty, interspersed with views of nature either falsely romantic or vulgar beyond reality; there is so much to animate and amuse us, and yet so much that we would willingly overlook, that I cannot help comparing the contrasted impressions which they make to those which we receive from visiting some great and ancient city, picturesquely but irregularly built, glittering with spires, and surrounded with gardens, but exhibiting in many quarters the lanes and haunts of wickedness. They have scenes of wealth and high life, which remind us of courts and palaces frequented by elegant females and high-spirited gallants, whilst their old martial characters, with Caractacus in the midst of them, may inspire us with the same sort of regard which we pay to the rough-hewn magnificence of an ancient fortress."

Other Dramatists. It is not possible within our space to continue, even in this faint outline, our review of the Elizabethan dramatists, so we must now dismiss many names in briefest mention, though most of them are almost as worthy of some detailed notice as Beaumont or Fletcher. PHILIP MASSINGER (b. 1583; d. 1639), who was laid in the same grave as Fletcher, at St. Saviour's, Southwark, was so variously associated with Fletcher and other dramatists in playwriting that it is difficult to form an estimate of his individual work. But he is certainly no less gifted in comedy than Beaumont and Fletcher, and in tragedy he displays real power. His only play that has held the stage is "A New Way to Pay Old Debts," a brilliant and mordant comedy. JOHN FORD (b. 1586) was a dramatist of real tragic power, to whom only the darker emotions of the heart seemed to appeal, for his plays are sombre and unredeemed by the finer feelings of fancy and imagination. His "Perkin Warbeck" is a good historical drama, and "'Tis Pity——" is a remarkable tragedy. He collaborated in several plays with THOMAS DEKKER (b. 1570), a prolific and able writer, both of tragedy and comedy, who in turn was associated with JOHN WEBSTER, of whose life hardly anything is known. Webster was a dramatist of extraordinary power in tragedy, and over his works gloom, profound and chilling, seems ever to brood. "The Duchess of Malfi" is his greatest play, and must rank with the finest of the period; but it is easy to understand how he had scant favour from contemporary audiences. THOMAS MIDDLETON (b. 1570; d. 1627) wrote many charming comedies, while WILLIAM ROWLEY (b. about 1585), an actor-playwright of no remarkable qualities, collaborated at various times with the five last-mentioned dramatists, and also with THOMAS HEYWOOD, who had a large share in the writing of 220 plays up to the year 1633, and is believed to have lived until 1648. "A Woman Killed with Kindness" has real pathos and simplicity to distinguish it, and may be accounted the best of Heywood's plays. JOHN MARSTON (b. 1575; d. 1634) was a poet of most unequal achievement, associated with Jonson and GEORGE CHAPMAN (b. 1559; d. 1634) in the production of "Eastward Ho," as noted above. Chapman was greater in comedy than in tragedy, "All Fools" being an excellent play of the former class, while his tragedies are usually marred by bombast and



ELIZABETHAN DRAMATISTS: SHAKESPEARE AND HIS

fustian. His great achievement was the translation of Homer's "Iliad" and the "Odyssey" into rhymed verse of fourteen syllables. These translations, despite numerous faults, are in many ways unsurpassed by Pope's more familiar versions of the same works, and well worthy of every reader's attention.

Last of the Elizabethans. With James Shirley (b. 1596; d. 1666) we reach the last of this school of dramatists; for though he was but a boy when the reign of the virgin queen ended, his early associates were the later Elizabethans, and all the influences on him were Elizabethan; he had come to manhood at the time of Shakespeare's death. Charles Lamb says of him: "James Shirley claims a place amongst the worthies of this period, not so much for any transcendent talent in himself, as that he was the last of a great race, all of whom spoke nearly the same language, and had a set of moral feelings and notions in common. A new language and quite a new turn of tragic and comic interest came in with the Restoration." This, rather than Campbell's somewhat perfervid panegyric of the dramatist, is a proper view of Shirley, for while the tragic and pathetic passages of his plays, which are chiefly tragi-comedies, are often distinguished by great tenderness and true feeling, he fails on the whole to rise to the level of his models, Beaumont and Fletcher and Ben Jonson.

The English Spirit. We have now reached the conclusion of a most important stage of our study, for on our knowledge of and sympathy with the poets from Chaucer to Shirley will depend much of our understanding of English Literature. The Elizabethans, especially, are the beacon-lights of the English spirit, if the metaphor will pass. To know them well is to have the whole character of England illumined for our better appreciation. They represent more directly than any body of writers in England, before or since, the spirit of their time and country. This may be thought an over-statement, when we remember how the spirit of the eighteenth century is reflected in the writers of the period. But that is not the real spirit of England; it is a passing phase; whereas the spirit of the Elizabethan age is no passing phase, but the very pulsing of England's heart. In a sense, the Elizabethans are more "in touch" with us of this later day than are the writers of the eighteenth century. We shall even find that the literature of the Victorian age, rich to abundance though it is in great writers and in great works, is not so thoroughly in tune with the English spirit as is that of the Elizabethan. For the creators of the latter were poets to a man, and the poet is ever the truth-teller. He is not so apt to temporise with passing moods and whims as the prose-writer is; he utters himself with greater freedom, fearless, because "It is in me, and shall out." Thus the age of Elizabeth remains for ever the epoch in which—with the awakening of all those varied energies that have since made the British Empire the unmatched wonder of the world's history—there lived, surely by no mere chance but inevitably, a splendid company of poets whose poetry enshrines for all time the English spirit—patriotism, heroism, idealism, the love of liberty, beauty, Nature, domesticity.

Morals and Sincerity. That the Elizabethan poets were as capable of expressing grossness as of voicing the noblest aspirations of the soul is no argument against them. Every country has its standard of good taste: an ocean wider than the Atlantic separates the English of to-day in matters of taste from their nearest neighbours across the Channel. And every age of any one country has had its own standard of good taste. That of the Elizabethan was assuredly different from that of our day; just as that of fifty years hence promises to be strangely different from the standard of twenty years ago. The Elizabethan poets—since, for all their superiority to the multitude, they were still men of their time—necessarily reflect in their writings the looseness of their age in the treatment of morals. It does not follow that they were one degree less moral than we are to-day; but they spoke of subjects which with us it is bad taste to discuss. They were, for that very reason perhaps, the more honest; and sincerity is the master-note of all the great Elizabethans; indeed, sincerity is the one infallible test of all enduring literature.

Nowhere is the value of sincerity so admirably appraised as in Carlyle's "Heroes and Hero-Worship," and we feel that, in order to appreciate this vital factor in all literature, the student might do worse than read that work at this stage, with his mind on this point alone. Sincerity lifts everything in which it is present on to a higher plane, and where we find it associated with other qualities of a derogatory kind—as we do in some, if not all, of the Elizabethan poets—it still remains the great preservative, purifying, vivifying the poet's work, in spite of all.

Supremacy of Shakespeare. And it is Shakespeare, again, who towers above his glorious company of contemporaries in his comparative freedom from all besmirching elements, but by that token he is, as we have already hinted, really less the mirror of his age—but more the mirror of the English spirit—than, for example, Beaumont and Fletcher. He is the most modern writer in our language. It would seem that in one fruitful moment the genius of England gave birth to a poet who interpreted his country to itself and to the world once and for all time; his thought and language being the everlasting mind and utterance of his race at its highest. His contemporaries are small when ranged beside him, yet mighty in their individual and collective strength. But after what has been said, it is surely unnecessary to insist further on the importance of gaining a good knowledge of Shakespeare and his contemporaries—this must be apparent to all who have come with us thus far in our studies. And we may now take leave of the Elizabethans by quoting the summary with which Taine begins his study of the theatre in his "History of English Literature."

"Forty poets, amongst them two of superior rank, as well as one, the greatest of all artists who have represented the soul in words; many hundreds of pieces, and nearly fifty masterpieces; the drama extended over all the provinces of history, imagination, and fancy—expanded so as to embrace comedy, tragedy, pastoral and fanciful literature—to represent all the degrees of human condition, and all the caprices of human invention—to express all the perceptible details of actual truth, and all the philosophical grandeur of general reflection; the stage disencumbered of all precept and freed from all imitation, given up and appropriated in the minutest particulars to the reigning taste and public intelligence: all this was a vast and manifold work, capable by its flexibility, its greatness and its form, of receiving and preserving the exact imprint of the age and the nation."

Such is the Elizabethan drama, the most important of all periods of English literature, not to the student only, but to the general reader who desires to possess a reasonable knowledge of our great literary heritage.

Continued

THE CHOICE OF BOOKS IN ELIZABETHAN LITERATURE

The subjoined list is by no means exhaustive, but it contains reference to the most convenient editions of the poets and to standard works in criticism and biography. We have purposely chosen only those books which, published at low prices, may be added to the reader's own private library. At public libraries many other and more expensive works are available to the student. It should be noted that some of the books are no longer included in the current lists of their publishers, but these are regularly to be met with at the secondhand dealers. The "Mermaid" series was originally published by Vizetelly at 2s. 6d., and latterly by Unwin, at 3s. 6d. Many of this admirable series are still in print, but the collector will find single volumes at almost any secondhand bookseller's.

GENERAL.
- *Specimens of the Elizabethan Drama.* From Lyly to Shirley. Edited by W. H. Williams. Clarendon Press. 7s. 6d.
- Marlowe's *Dr. Faustus* and Greene's *Friar Bacon and Friar Bungay.* Edited by A. W. Ward Clarendon Press. 6s. 6d.
- *The Shakespeare Anthology.* Edited by Prof. Arber Frowde. 2s. 6d.
- *The Jonson Anthology.* Edited by Prof. Arber. Frowde. 2s. 6d.
- *Shakespeare's Predecessors.* By J.A.Symonds. 1884.
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Group 13
GEOGRAPHY
6

Continued from page 690

THE GEOGRAPHY OF EUROPE

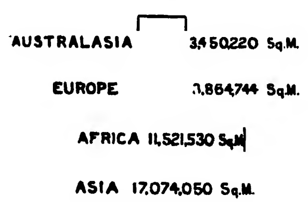
Land and Water of the Old World. Europe and Asia Compared and Contrasted. Position, Climate, Plains, Rivers, and Productions of Europe

By Dr. A. J. HERBERTSON, M.A. and F. D. HERBERTSON, B.A.

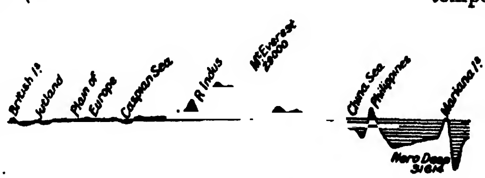
The Old World. The Old World [56] is the greater of the two huge islands into which most of the land of the earth is grouped. It contains 32,000,000 sq. miles out of an estimated 55,000,000 sq. miles, or approximately three-fifths of the total land area. Viewed as a whole, it is roughly rhomboidal in shape, and very compact, the seas which penetrate it being insignificant in comparison with its vast extent, though of the greatest importance historically and commercially. The most northerly point of the Old World is about 12° from the North Pole—that is, about half way between the Arctic Circle and the Pole. The most southerly point is about four and a half times that distance from the South Pole.

56. THE OLD WORLD
Showing the continental land masses of the eastern hemisphere

South of the Equator, as we have seen, the land tapers rapidly, so that by far the greater part of the Old World lies in the northern hemisphere. Its greatest extension from east to west coincides approximately with the parallel 40° N. lat., which passes near Madrid, the capital of Spain; Constantinople, the capital of the Ottoman Empire; Samarkand, one of the great rallying points of Russian Central Asia; Peking, the capital of China; and the northern part of Honshiu (or Hondo), the largest of the islands of Japan. The greatest extension of the Old World from north to south is along the meridian of 20° E. long., which passes near Tromsö, in the north of Norway; Cracow in Poland; Budapest, the capital of Hungary; and Cape Town, in the extreme south of Africa.



57. COMPARATIVE AREA OF THE CONTINENTS OF THE OLD WORLD



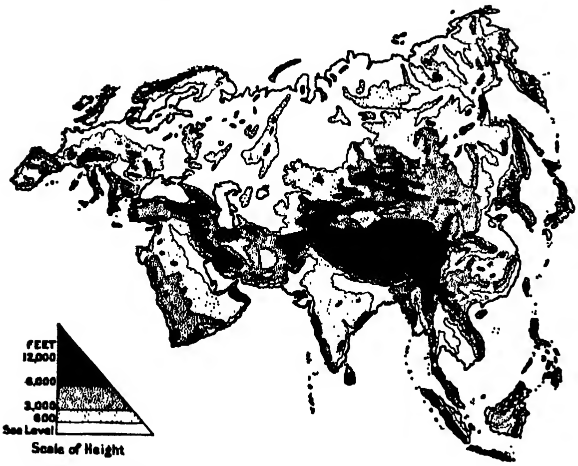
58. A SECTION ACROSS EURASIA, SHOWING THE GREATEST HEIGHT AND THE GREATEST DEPTH IN THE WORLD

Oceans of the Old World. The northern shores of the Old World are washed by the practically ice-bound Arctic Ocean, its western shores by the Atlantic, its south-eastern and southern shores by the Indian Ocean, and its eastern shores by the Pacific. From these oceans many arms of the sea penetrate deeply into the land, two of which must be specially noticed here. The Mediterranean Sea, by a breach in the west, forms an arm of the Atlantic, and separates the southern shores of Europe from the northern shores of Africa. The Red Sea, an arm of the Indian Ocean, all but severs the east coast of Africa from the west coast of Asia. The continent of Africa (11,500,000 sq. miles) is thus nearly cut off from the main mass of the Old World, and is connected with it only by the narrow Isthmus of Suez, between the Red Sea and the Mediterranean, which is little more than 80 miles wide. The remainder of the Old World forms the double continent of Eurasia, the western part of which is known as Europe (3,800,000 sq. miles) and the eastern part as Asia (17,000,000 sq. miles) [57].

Home of the Human Race. Eurasia, with an area of nearly 21,000,000 sq. miles, or approximately two-fifths of the land of the globe, is the most varied and interesting division of the earth's surface. Off its shores lie the greatest ocean depths, and its continental portion contains the culminating height, the vastest mountain area, and the most extensive plains in the world [53]. Every zone of temperature and climate is represented, from Polar to Equatorial, and the range of economic products is consequently extraordinarily varied.

It is probably the original home of the human race, and by far the most densely populated portion of the globe. No enduring civilisation has ever yet originated outside its borders, for the great commonwealths of the white race in other continents are but applications under favourable conditions of principles discovered by the pioneer people of Eurasia. Eurasia, moreover, has been the cradle of all the exalted religious faiths of the world, and thus in every sense it is the great motherland of the world.

Europe and Asia Compared. The structure of Eurasia will not be described in detail here. But one fact is too significant to be overlooked. That fact is the unity of physical structure which characterises Eurasia and makes it, in spite of the conventional division into two continents, really but a single one. Physically, it is impossible to say where Europe leaves off and Asia begins, and the boundary between the continents has shifted with the course of history [59].



59. PHYSICAL MAP OF EURASIA
The solid black patch corresponds roughly with the country of Tibet. The majority of the large towns are below the level of the 600 feet contour

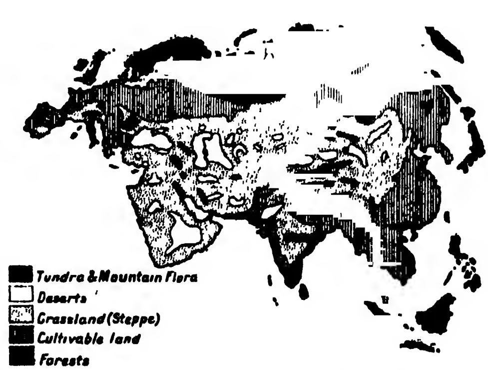
Any good map will show how the great natural features are continuous across both continents. Broadly viewed, the northern part of Eurasia is one vast lowland, extending from the shores of the Atlantic almost to those of the Pacific. South of this we trace across Europe and Asia, from ocean to ocean, a zone of varying breadth and height, but everywhere of considerable elevation. In Europe this zone of elevation, which we may call by the general name of the Eurasian Mountains, is represented by the mountains of Northern and Southern Spain, the Alps, Balkans, and Caucasus, and in Asia by a complex series of double and triple mountain chains, culminating in the great Himalayas. South of the Eurasian mountain system, which attains its greatest breadth as well as its greatest height in Central Asia, is a series of tapering peninsulas, all mountainous, and connected with the mountain core to the north.

All these run south—into the Mediterranean Sea in Europe, and into the Indian Ocean in Asia. Notice, however, that while in Asia these extend far south of the tropic of Cancer, no part of Europe is within 12° of it. Asia, therefore, has a greater variety of climate and products than Europe, which lies wholly in temperate latitudes.

Vegetation. Corresponding with this symmetrical arrangement of highland and lowland from east to west across Eurasia, there is, allowing for differences of elevation, distance from the sea, and other modifying circumstances, a similar arrangement of the zones of climate, which finds a broad expression in the natural zones of tundra, forest, steppe, desert, etc., already described. These may be traced across Eurasia [60], but they are best marked where the continent is widest—that is, in Asia. The tundra, a mere narrow fringe in Europe, forms a broad band in Asia, which has a much greater extension of land within the Arctic circle. Similarly, the belt of temperate forest which covers Northern and much of Eastern Europe attains vaster dimensions in the great plains and highlands of Asia.

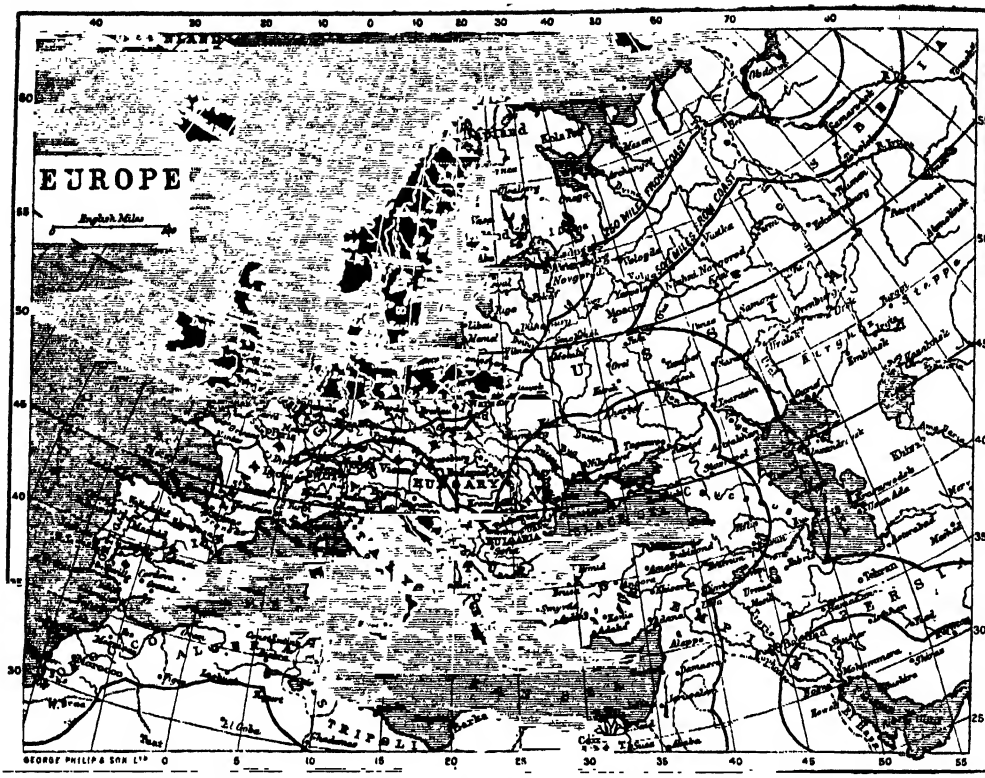
The steppes of Europe, which may be traced across Hungary and Southern Russia, widen similarly as we go east across the southern part of the Asiatic lowland. Towards the drier interior they pass gradually into the desert. This desert belt, which is a mere thread in Europe, extends across the whole of Central Asia, through Arabia, Persia, Russian and Chinese Turkestan, and Mongolia, broken by oases great or small where irrigation is possible. The southern boundary of the Eurasian desert belt may be broadly indicated by a line drawn from Aden, along the Indus valley to the Pamirs, and south of the deserts of Mongolia to Peking. South of the central mountains and deserts lie the monsoon lands, in which the rainy season occurs at the season of highest temperature.

The monsoon winds, as already explained, do not blow far outside the tropics, and this zone



60. VEGETATION MAP OF EURASIA
The tundra lands lie along the northern lowlands, bordering the Arctic Ocean; the mountain flora occurs in the high mountainous regions of Central Asia. The cultivable land includes forests in isolated areas

is consequently absent in Europe. Wherever the rainfall is sufficient the monsoon lands are fertile agricultural lands, often of the savana type. As the equatorial region of constant heat and moisture is approached, the vegetation becomes more exclusively and



61. GENERAL MAP OF EUROPE, SHOWING BOUNDARIES OF COUNTRIES, AND AREAS WITHIN 250 AND 500 MILES FROM THE SEA-COAST

distinctively tropical, and in the Malay Peninsula and the adjacent islands are dense forests of the true equatorial type.

Europe and Asia Contrasted. Why, then, it may be asked, in view of these similarities, has the destiny of the eastern and western continents of Eurasia been so different? Such a question is well asked, but it cannot be answered without a very profound knowledge of the geography of both continents. It may be pointed out, however, that the physical features of Asia, though broadly comparable to those of Europe, are on a vastly greater scale. Barriers of impenetrable mountain, desert, and forest cut off the interior from the sea, and hinder the free movement of peoples and ideas. The country is densely populated only where fertile lowlands open to navigable seas. Here the Indian and Chinese civilisations are highly developed; but they have been little influenced by the rest of the civilised world, and have exercised little influence upon it, because India and China are backed by the loftiest mountains in the world and by some of its most formidable deserts.

The barrier of the desert is practically absent in Europe, the mountains are less formidable in height and breadth, while many other circumstances, of which more will be said later, have combined to promote that free movement of population on which depends the circulation of new ideas and new discoveries, and consequently a rapid progress in the arts of life and of civilisation generally.

EUROPE

At the beginning of our study of the geography of the different regions of the world we are confronted with one of the great difficulties of the subject—what to leave out. Our maps are crammed with the names of seas, mountains, rivers, and towns, and about each of these much of undoubted interest might be said. This would make a series of large volumes, and a similar series might then be written describing how men live in different parts of the world, and how they obtain, utilise, and exchange each of the innumerable animal, vegetable, and mineral products which the earth offers. In a series of articles like the present, where there is room only for the most essential of the myriads of interesting facts there are to know about the world and its people, much space can be saved if those who use them do not expect to find in the text lists of names which they can and ought to find out for themselves in the carefully chosen maps which illustrate them. A student who is not prepared to consult maps as frequently and as carefully as the text is advised to lay aside the study of the subject. In the following pages it will be assumed that the student has ascertained the general position of the various countries of Europe [61].

What it is essential that we should know

about all the countries to be studied are the circumstances which affect them individually as the possible or actual home of man. These include its position in latitude and longitude, which determines its general climate, and consequently the range of its possible products; the distribution of its seas and land, which, besides their effect in modifying its climate, aid or hinder free communication between all parts, and thus, indirectly, the rate of progress in civilisation and commerce; the distribution of its highlands and lowlands, which act in the same direction, and also exercise a great influence on the density of population in particular areas, and the nature of its natural products.

Position of Europe. To state the position of Europe in latitude is to state its relation to the Pole and to the Equator—that is, to polar and tropical conditions of climate. To state its position in longitude is to state its relation to other parts of the world in similar or different latitudes. To know its latitude is to possess far more actual information about it than to know its longitude.

The only satisfactory way to ascertain latitude or longitude is to look at a map, or, better still, a globe, and to reflect at the same time what the figures mean. If this is done for Europe, it will be seen that the parallel of 70° N. cuts the extreme north of the continent, and that very little land lies north of it. The continent is but little wider where the Arctic Circle (67½°) cuts it, and only a few hundred square miles are within it. This means that practically no part of Europe is within the polar zone. The solid core of the continent lies mainly between 55° and 45° N. This means that the great bulk of the continent is in the cool temperate belt. The most southerly of the southern peninsulas, Spain, just reaches 36° N. This means that only the extreme south of Europe is in the warm temperate belt.

Excluding Iceland, which is, of course, part of Europe, the parallel of 10° W. may be taken as the western limit of the continent proper. It cuts the extreme west of Ireland, and passes a little west of the west coast of Spain. The very irregular land frontier with Asia is about 74° E. at its most eastern point, and for a considerable distance roughly runs along 60° E.

The boundaries of Europe should be looked out on the map.

The Seas of Europe. Europe, which may itself be regarded as a large irregular peninsula of Eurasia, is a continent of seas, peninsulas, and islands. The most important of these are shown and named in the map.

The sea penetrates deeply into the land, both north and south, greatly reducing the breadth of the continent west of 30° E. long. The Mediterranean Sea, in the south, is land-locked but for the Strait of Gibraltar, nine miles broad, its only exit and entrance. Look out on the map its great gulfs—the Lion Gulf, the Gulf of Genoa, the Adriatic Sea, the Ægean Sea—and notice in particular the Strait of the Dardanelles, leading through the Sea of Marmora, by the narrow Bosphorus, to the Black Sea and the Sea of Azov. The Caspian Sea, farther east, is entirely land-locked, and has no connection with the Mediterranean. In the north there is also an almost land-locked but much shallower sea, the Baltic, with its gulfs. The only exit from the Baltic is by the Sound, between Sweden and Denmark, leading through the stormy Kattegat and Skagerrak to the wider North Sea, from which the only practicable passage to the Atlantic Ocean, its great gulf the Bay of Biscay, and the Mediterranean Sea, is by the narrow English Channel. The Arctic Ocean, to the north of Europe, has one arm, the White Sea, which gives Russia its port of Archangel.

This cutting up of the continent by the sea is very important. Not only does it give to almost every important country access to at least one sea, but it makes the climate of Europe much more uniform than would otherwise be the case. Only in the extreme east, in Russia, is any part of Europe more than 500 miles from the sea, and only there is a really continental climate experienced.

Climate. The climate of a country, so far as its temperature is concerned, is best understood by examining the direction of the isothermal lines, and, in particular, the isotherms for January, the coldest, and July, the hottest month of the year. Temperature is affected by many other causes than latitude, for the isotherms do not correspond with the parallels of latitude, though they do so much more nearly in summer than in winter, and more nearly in the western than in the eastern part of the continent. The western half of Europe is exposed to the westerly winds from the Atlantic, which, in winter, are mild and rainy, and, in summer, cool and rainy. The reason of this has already been explained.

The influence of the Atlantic winds on the climate of Western Europe is well shown by the manner in which the July isotherms are bent north in eastern Europe. In July, Kazan, in Russia, in the latitude of Edinburgh, is as warm as Oporto in Portugal. Archangel, on the White Sea, is as hot as Edinburgh, though it is 20° farther north. In winter, when the severity of the winter is greatly lessened in Western Europe by the Atlantic winds, the eastern part suffers from intense cold. No one who has ever noticed the remarkable manner in which the January isotherms bend south in Central Europe, and has reflected what this bending south means, is ever likely to forget it [62].

Water freezes at a temperature of 32° F. The isotherm for this temperature, the freezing point, shows that Iceland, nearly all Scandinavia, the greater part of Germany, Austria-Hungary, the northern Balkan States, and all Russia (except the southern part of the Crimea), are held in the grip of frost. In January it is warmer in the extreme north of Scotland than in Sofia, the capital of Bulgaria, which is in the latitude of Rome. To show how severe is the winter of Eastern Russia, take the isotherm of 14° F., which indicates 18° of frost. Shown on a map it would pass east of St. Petersburg, and

curve south almost to the Caspian Sea, in the latitude of Paris. Compare this with the climate of the British Isles, where weather cold enough for several days' skating is the exception rather than the rule, or with that of France, Western Germany and the Mediterranean lands.

We summarise the climate of Europe, therefore, by saying that it is equable in the west and south, and extreme in the east.

Distribution of Rain. As a result of the influence of the Atlantic on the climate of Europe, we should expect to find the west of Europe wetter than the east, and the western slopes of mountains wetter than the eastern. This the rainfall map of Europe shows to be the case [63]. The rainy Atlantic winds strike full on the mountainous shores of Scandinavia, upon the British Isles, and particularly Ireland, and less directly upon Northern

62. EUROPE, SHOWING SUMMER AND WINTER TEMPERATURES

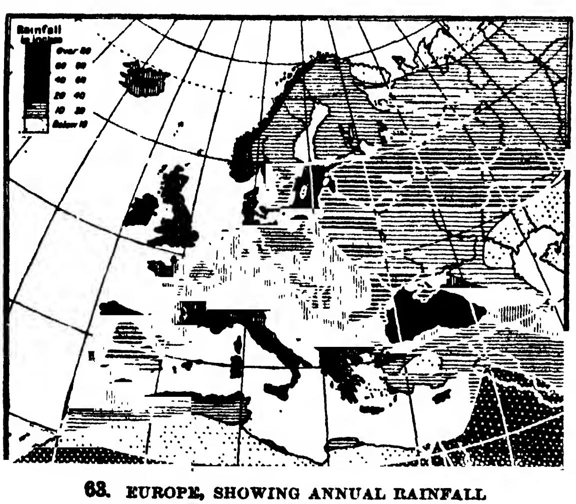
shore of the Spanish peninsula. Ireland and the western half of Great Britain are considerably wetter than the eastern parts, as we may learn by unfortunate experience if we spend a holiday on the western shores of our island. In Scandinavia the winds part with much of their moisture on the western slopes of the western mountains, while the eastern slopes, and indeed all of Sweden, are comparatively dry.

In this part of Europe the rainfall is fairly equally distributed at all seasons, but is heaviest in autumn and winter. Another area which is shown in the map as having a high rainfall is the mountain district of Switzerland, with the mountains to the north and south. The reason why mountain regions have a relatively high rainfall has already been explained, and should be borne in mind. The peninsulas to the south, and the Mediterranean lands generally, have dry summers, and the rainfall is in the winter half-year. The reason of this, the shifting north of the dry area in the belt of calms at the northern limit of the trade winds in summer, and the extension southwards of the rainy westerly winds in winter, has already been explained. In the east of Europe the map shows that few areas have as much as 20 in. of rain in a year, against 80 in. in the wettest parts of the British Isles. Round the Caspian Sea there are regions with less than 10 in. a year, where the desert conditions of Central Asia are beginning to be felt. The other very dry area of Europe is in Central Spain, where the rainfall is under 20 in.

The Lowlands of Europe. It is no longer thought necessary to learn by heart the names and heights of the highest and most inaccessible peaks of a continent or country. What we want to know, for most practical purposes, is where the lowlands are and how to get from one to another by the natural breaks or passes in the mountain chains.

Looking at a map of Europe [64] in which the distribution of high and low ground is shown, we see that the lowlands of Europe are very extensive, and that more than half the continent is less than 600 feet above sea-level. A great lowland, forming part of the Eurasian lowland, runs through the southern part of the British Isles, Northern France, Belgium, Holland, and Northern Germany, and widens out into the great plain of Russia, which stretches on, far beyond the boundaries of Asia, almost to the Pacific. In Europe it would be possible to walk from the frontier of Asia to the Bay of Biscay, by a fairly direct route, without ever seeing a hill as high as the Eiffel Tower in Paris.

North and south of this vast



63. EUROPE, SHOWING ANNUAL RAINFALL
The darker the tint, the heavier the rainfall

lowland are bands of much higher land. To the north are the mountains of the British Isles and Scandinavia, separated from each other by the shallow North Sea. To the south, the highlands are broader, higher, and much more irregular in arrangement, forming part of the great Eurasian mountain system, which stretches from the Atlantic to the Pacific. To this system belong the mountains of Spain, the Pyrenees between France and Spain, the Central Plateau of France, the Vosges, Black Forest, and other mountains of Southern Germany, the Jura and Alps of Switzerland, the Apennines, running south from the Alps into Italy, the mountains of Bohemia, the Karpathians of Hungary, and the ranges running from the Alps through the Balkan peninsula, as well as the Caucasus, between the Black and the Caspian Seas, forming part of the frontier between Europe and Asia. A number of smaller, fertile lowlands lie south of these Central Mountains, the largest of which are the plain of Lombardy, between the Alps and the Apennines, the plain of Hungary, enclosed by the Alps, the Karpathians and the mountains of the Balkan peninsula, and the plain of Roumania or Valakhia (Wallachia), south of the Karpathians.

Rivers. A long though not continuous barrier of mountains is thus interposed between the north and south of Europe, and has always rendered communication between north and south a matter of some difficulty. The fact that this barrier lies far to the south, with the longer, gentler slope to the north, causes most of the great rivers of Europe to flow north to the North and Baltic Seas, and gives to these seas, and the countries which border them, a very great importance. The only notable exceptions among the rivers of Europe are the Rhone, which flows generally south to the Mediterranean, and the Danube, which forces its way east to the Black Sea through one mountain barrier after another, forming the great physical, commercial, and political link between Central and Eastern Europe. The Volga and other great rivers of Russia also flow south, but they have no such importance for Europe as a whole as has the Danube. Note on the map how each of the principal countries of Europe has its great river linking its seas with the mountain centre of Europe. In France the Seine, the Loire, and the Rhone connect the English Channel, the Bay of Biscay, and the Lion Gulf of the Mediterranean with the centre of Europe. Germany has the magnificent Rhine, which enters the North Sea by way of Holland, as well as the Elbe, Oder, Vistula, and others of less importance, bringing her distant mountain provinces into touch with the many busy ports which fringe the North and Baltic Seas [84].

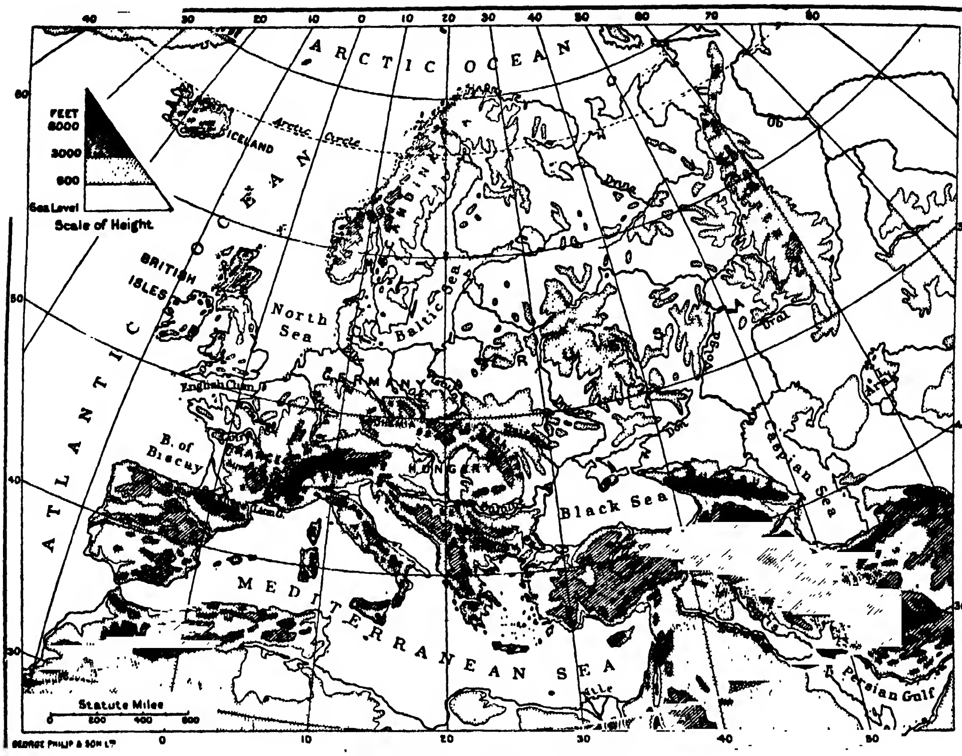
Austria-Hungary has the Danube, Italy the Po, and in Russia the Dnieper may perhaps be reckoned in the same group of rivers. Some of these rivers, with their tributaries, form the great natural lines of communication across Europe. The easiest route across Europe is by way of the Rhine and its upper tributaries to the famous walled city of Luzern, whence the lake of the same name leads deep into the Alps, through the core of which is cut the famous St. Gothard Tunnel, to strike one of the tributary valleys of the Po, leading to the plain of Lombardy. Hardly less important is the route by the Seine and Rhone valleys and the Mont Cenis Tunnel through the Alps to the head of another tributary valley of the Po, and thus to the great centres of Italy. The principal route to the east goes by the Rhine and Danube valleys.

Vegetation. The natural zones of vegetation—tundra, forest, steppe, and even desert—and their relation to each other and to the corresponding zones in Asia, have already been described [60]. In Europe, however, man has been at work for centuries—if not millenniums—in transforming the face of the earth. Impelled by the need of fuel, and still more of land on which to sow and reap, he has steadily cleared the forests—at first, no doubt, along the rivers, and later up the side valleys and far up the hillsides. In Central Europe only the higher slopes of the mountains are still forested, and in the valleys below orchards and meadow land have replaced the dark pine-woods. Nature, however, still asserts herself, and sets limits to the regions in which particular plants can be cultivated.

Of all the chapters in the eventful history of our race none is more interesting than that of agriculture. When history begins this art was already old, and as man's knowledge of the world has widened, plant after plant from other lands has been introduced into Europe with more or less success. Many of the most familiar cultivated plants are really not of European origin at all.

The Cereals. The most important plants cultivated by man are the cereals, or bread stuffs, from which the staff of life is manufactured. Of these the most productive as well as the most palatable is wheat, which is grown all over Europe south of the North and Baltic Seas, as well as in the British Isles. In the hotter, drier parts of the southern peninsulas it is largely replaced by maize. All through the wheat belt rye, oats, and barley are grown on the poorer soils, the latter cereal being so hardy that it can be cultivated as far north as the Arctic Circle, though of course with a diminishing yield.

Fruits. Next in importance to the cereals, and almost as ancient, are the fruits. These include many different varieties adapted to different climates. The king of the northern fruits is the apple, which has made famous the orchards of Southern England and Northern France. In the rather drier countries of Central Europe the stone fruits—cherry, apricot, and plum—become more important, the latter being one of the staple products of the northern Balkan provinces. The Mediterranean has two famous fruits, anciently reckoned as the best gifts of the gods to man. These are the olive,



64. PHYSICAL MAP OF EUROPE

with its nutritious oil, and the vine. The vine, however, though it loves the sunny South, can be grown with care far north of the Central Mountains, on the terraced southern slopes of the hills. A few hundred years ago it is said to have flourished in these islands and in Northern France, though we must suppose that its juice must always have lacked something of the mellow sweetness which only long, steady sunshine can give.

The Root Crops. A third group, hardly less important, is the root crops. These are among the youngest of the staple crops of Europe, but their introduction has caused a revolution in the conditions of life. Formerly cattle were killed in late autumn because winter food was not to be had. The flesh was salted down or smoked, and this unpalatable fare formed the principal winter diet.

The introduction of root crops of the swede type has made it possible to have fresh meat and milk all the year round. The potato, transported from the New World, has brought a cheap and palatable food within the reach of all classes. A recent but very important food crop is the sugar beet, which is largely grown all over France and Germany, and might with advantage be introduced into this country.

Fibre and Fodder Plants. Another group of plants is grown for fibre. Of these the most useful are flax and hemp, largely grown around the Baltic. Besides these great groups we may note plants grown for fodder, including grasses of various kinds. In Southern Europe the principal fodder plant is lucerne, a pulse with long roots, which is better suited to the drier climate. The pulses [see BOTANY] are widely grown, but are specially important in the Mediterranean region. In the same region the mulberry is largely grown to feed silkworms Many other plants, such as hops, used in the making of beer, might be mentioned, without exhausting the useful plants grown in many parts of Europe.

Animals. The ancient wild animals of Europe have now almost disappeared, and have been replaced by the domestic animals—cattle, horses, sheep, goats, which are kept wherever pasture is available. The goat and the sheep, the hardiest and least dainty, have a wide range. The goat does well in the Mediterranean region. The sheep of many parts and particularly of Britain and Saxony, are famous, as are the horses of Hungary. The Mediterranean region is too dry for cattle, and the mule becomes more important than the horse. In the extreme north of Europe the reindeer is the only domesticated animal, serving for purposes both of draught and food.

Continued

OUTLINES OF EDUCATIONAL TOURS ABROAD

Model Itineraries indicating how in the Least Time and with Minimum Expense Tourists may see Germany, Norway and Holland

By J. A. HAMMERTON and WILLIAM DURBAN, B.A.

GERMANY

Germany is not, on the whole, a land of imposing natural scenery, but it is the seat of the most intellectual civilisation in the world. Its cities are almost all quaintly interesting, historic, and beautiful, and its agrarian tracts uniquely attractive to the student of agricultural conditions. Its cathedrals are epitomes in stone of the religious history of a thousand years, and its picture galleries rival those of Italy. Travel is exceedingly comfortable, inns are excellent, the people sincere and reliable; the manners and customs are fascinating with the survivals of picturesque mediævalism, and the development of modern industry is astonishing. Germany is specially interesting as the link between North and South, and between East and West. Fresh and bracing with the breath of the Baltic, it is with its lovely vineyards suggestive of the attributes of the South; while its exquisite scenery along the Rhine, in the Black Forest, and in Saxon Switzerland can scarcely be excelled anywhere in Europe for those who aim at the maximum of enjoyment with the minimum of fatigue.

As Germany is a very populous country, and its attractive cities are fairly distributed over the whole area, the tourist who wishes to gain a general acquaintance with this extremely interesting land has a great latitude of choice. But a delightful trip of a fortnight is easily planned for those who go for the first time.

A Fortnight in Germany. The wisest

gramme of the tour would then be as follows:

First and Second Days. In Berlin the main objects to be visited are the *Palace*, the *Royal Library*, with its 800,000 volumes; the *Picture Gallery*, containing 1,500 paintings; the *University*, attended by 4,000 students; and the old and new *Museums*. These will occupy the first day. The second day will be delightfully spent among the interesting open-air sights. The famous *Unter den Linden*, or grand double avenue of lime-trees; the splendid park called the *Thier Garten*, and the *Zoological Gardens*, which are among the finest in Europe; the magnificent *Brandenburg Thor*, or Triumphal Arch; the noble equestrian statue of *Frederick the Great*; the *Warriors' Monument*, and the Royal Chateau of *Monbijou*, all invite pleasant attention.

Third Day. A day is ample for the inspection of Potsdam, after Berlin the finest and best built city in Prussia, with the sights in the environs. These are the *Triumphal Arch*, copied from Trajan's at Rome, the celebrated *Sans Souci Palace*, erected by Frederick the Great; the villa called *Charlottenhof*, with its lovely gardens; and the old *Royal Palace*, with its Grand Colonnade.

Fourth Day. This may well be spent at Dresden, where the "things to see" are compactly situated. The *Japan Palace* contains the immense Public Library, and in the Green Vault the wonderful collection of pearls, precious stones, and curiosities. The *Court Theatre* is a magnificent edifice, but the pride of Dresden is, of course, the *Picture Gallery*. Here, amongst many masterpieces, are Raphael's "Sistine Madonna," Titian's "Tribute Money" and "Venus," Correggio's "La Notte," Da Vinci's "Francesco Spraga," and numerous works by Rubens, Vandyke, etc.

Fifth and Sixth Days. Two days must be devoted to Leipzig. Life here is full of fascination. The chief of the sights are the beautiful *Rosenthal Park*, the stately *Rathhaus*; the *Gewandhaus*, famous for its concerts; the old *Pleissenburg Castle*, the fine *Museum*, the *Grand Theatre*, the *University*, with 3,000 students, and the *Conservatorium of Music*. If the tourist is in the city at New Year, or Easter, or Michaelmas, he will be fortunate in seeing the marvellous Trade Fair held three times a year; the famous Book Fair being also held at Easter.

Seventh Day. A short journey takes one to Halle. Here are striking sights, including *Handel's Monument* and the house where the musician was born; the ancient *Red Tower* in the Market Place, the fine *Town Hall*, the *University*, and that most famous orphanage in the world, the *Francke Institution*, with 4,000 inmates. All can be seen in a day.

Eighth Day. Near at hand is Wittenberg, which claims a day. It is full of memories of Luther and Melancthon, whose graves are in the *Schloss Kirche*, where Luther preached, and to the doors of which he nailed his theses. Their monuments are in the market, and *Luther's House* is a wonderful museum of his relics.

Ninth Day. Although Magdeburg and Brunswick are charming with their quaint, historical aspect, one day is sufficient to see both towns. The old thirteenth century *Cathedral* in the former contains Tetzel's great money-box, and in front of the fine old *Town Hall* is the monument to *Otho the Great*, erected

relics brought from the Holy Land by Henry the Lion. In the *Museum* are works of art by Dürer, Rembrandt, Holbein, Guido, Angelo, etc. A fine avenue of lindens leads to the *Ducal Palace*, a very imposing edifice.

Tenth Day. This could be devoted to Hanover and Hildesheim, which can both be seen in the time. In Hanover the curious old streets in one part of the city, the ten bridges over the Leine, the *Column of Victory* in the Waterloo Platz, the stately *Town Hall*, dated 1439, the *Royal Library*, the fine *Royal Palace*, and the splendid *Theatre* are all worth special attention. In Hildesheim are the most wonderfully picturesque mediæval wooden houses in Europe, with balconies on their upper stories, and marvellous carved gables and walls. The eleventh century *Cathedral* has magnificent bronze gates of that period, as well as lovely paintings on glass. The *Church of St. Michael* is an ancient basilica. On the wall of the *Church of St. Godehard* is a rose-tree supposed to be nearly a thousand years old.

Eleventh and Twelfth Days. The traveller reaches the beautiful Rhine at Cologne, with its glorious *Cathedral*, whose twin towers soar to the height of 500 feet. Here are the reputed skulls of the three Wise Men from the East. The *Church of St. Ursula* contains the bones of 11,000 virgin martyrs, and at the *Church of St. Gereon* are the

bones of 6,000 Theban martyrs. In *St. Peter's* is the famous altar-piece by Rubens, representing the Crucifixion of St. Peter. To Cologne and the neighbourhood two days may well be given.

We have allowed for a day's journey at the beginning of the tour, and the fortnight's progress will end with the day required for returning to London, and the tourist will have the satisfaction that he has gained an excellent acquaintance with the most important region of Germany, the heart of the Empire.

Longer Tours. *Three weeks* would give the visitor the opportunity of including at least a portion of South Germany, for it would enable him to go, after seeing Dresden, down to Munich, the splendid Bavarian capital, then to take in Nuremberg, Ratisbon, and Heidelberg, resuming the above tour by going from Heidelberg up to Leipzig. *A month* would enable the tourist to see most of the Rhine, to go also to the Falls of the Rhine at Neuhausen, and to spend three days in the Black Forest.

Fares from London to Berlin. *Viâ* Harwich and Hook of Holland or Flushing: Single, £4 6s. 9d., £3 2s.; return, £6 4s., £4 8s. The fares *viâ* Hamburg to Berlin are each way (with no reduction on return ticket). First class, £2 14s.; second class (train), with first class on boat, £2 5s. 6d.; second class throughout, £2 0s. 6d. Train fares in Germany are slightly cheaper than in England. The second-class carriages are often superior to the first class in England.

Cost of Living. In Germany this is rather less than in most Continental countries. Good, wholesome food is to be obtained everywhere in abundance. Bread is everywhere excellent, and both meat and drink are under strict Government supervision. It is an excellent plan to dine at the popular restaurants. The old-fashioned and unassuming hotels will often be found as comfortable as the more pretentious modern establishments. Germany is a true homeland of substantial comfort.

Books to Read. Literature about Germany is abundant. Longfellow's "Hyperion" is the best for reading on the journey, and almost as delightful is Bayard Taylor's "Views Afoot." Excellent are "German Life in Town and Country," by W. H. Dawson; "German Life," by H. Mayhew; "Pictures from Germany," by Dr. Green; and "Rambles in Germany," by Hon. F. St. John.

HOLLAND

The English visitor to Holland for the first time is astonished at what a new world he has reached in a few hours. Country, people, customs, language, style of buildings, dress, and methods of business are all strange, quaint, and striking. The home of the historic Dutch people is a phenomenal country, full of extraordinary natural characteristics. It is the lowest land in the world, most of it lying several feet below the sea-level, and needing the protection of the marvellous system of dykes. Countless canals intersect the land in all directions. The lofty and narrow houses, constructed of red brick and white cement, the numerous odd-looking windmills, the trim tulip gardens, and the rows of poplars stretching along the dykes and canals for miles, impart a unique aspect to the view from every point.

A Week in Holland is sufficient for gaining some knowledge of the country well worth acquiring. It should be spent in visiting Amsterdam, Marken, Zaandam, Haarlem, The Hague, Scheveningen, and Delft. More cannot be accomplished, but the tourist will have enjoyed a memorable week.

A FORTNIGHT IN HOLLAND. FIRST DAY. ROTTERDAM: The *Boompes*, or handsome and busy quay, planted with fine trees. The *Groote Markt*, with famous bronze statue of Erasmus. The *House of Erasmus* in the Eijde Kerkstraat. *Boymans' Museum*, with fine picture-gallery, containing some famous works of Rembrandt, Hals, Ruysdael, Van Ostade, Hobbema, etc. The fine *Park*. *Zoological Gardens*.

SECOND DAY. GOUDA: The *Groote Kerk*, with its far-famed 42 stained windows containing Scripture subjects. The *Museum*, with curious local antiquities and fine pictures.

THIRD DAY. UTRECHT: The *Cathedral* of St. Martin, with beautiful Gothic cloisters and great vaults, in which are the hearts of the German Emperors Conrad II. and Henry V. Cathedral Tower, 338 ft. high, with chime of 42 bells. The view takes in nearly all Holland. The *Museum of Arts*, in which are famous pictures, the finest being various works of De Keyser and Van Schoreel.

FOURTH DAY. AMSTERDAM: The magnificent central square called the *Dam*, with the lofty monument surmounted by the *Statue of Concord*. The *Royal Palace*, built on nearly 14,000 piles, with splendid Council Chamber, and many fine pictures by Bol, De Wit, Flinck, Eeckhout, and Wappers. The *Tower*, crowned by gilded ship, gives a wonderful view from the summit. The *Nieuwe Kerk*, with famous and beautifully carved wooden pulpit, and several monuments of noted admirals, including De Ruyter. The *Stadhuis*, with famous pictures by Bol, Hals, Flinck, etc. The *Ryks Museum*, the finest picture-gallery in Holland, with Rembrandt's "Night Watch," etc. The *Zoological Gardens*, the finest in the world next to those in London.

FIFTH DAY. MARKEN: A singular island. Famous for the curious costumes of its primitive people and its houses on artificial mounds or "hills of refuge." The *Zuider Zee* is seen to advantage here.

SIXTH DAY. ZAANDAM: A very typical Dutch town. *Hut of Peter the Great*, an extraordinary historical relic. The 400 windmills along the bank of the Zaan.

SEVENTH DAY. ALKMAAR: *Town Weighing-house* with handsome tower, in front of which, on Fridays, is arranged the most wonderful cheese market in Europe.

EIGHTH DAY. HAARLEM: Thriving manufacturing town, but wonderfully clean and very attractive. Many pretty gardens and extensive promenades along the Spaarne. The *Groote Kerk*, with the world-famous organ, long the largest in the world. Public performances at noon on Tuesdays and Thursdays. *Town Hall* with museum, containing pictures by national artists, especially Hals. The *Park*, with beautiful beeches. The magnificent *Tulip Gardens*, which largely supply the world with the choicest and most costly bulbs.

NINTH DAY. LEYDEN: Very ancient and charming city, on an arm of the Rhine. Gothic Church of *St. Pancras*, with singular towers, and 38 massive interior buttresses. The Church of *St. Peter*, the largest in Leyden, with the tombs of its most famous men. The *Botanic Garden*, with hot-houses containing magnificent exotics of East Indies.

TENTH DAY. THE HAGUE: One of the loveliest cities in the world. The fashionable pleasure city of Holland. Surrounded by glorious woods. The

Vijver, or Fish Pond, a beautiful sheet of water in the middle of the town, with islands and swans. The *Binnenhof*, a curious mediæval pile, in which are many of the municipal and Government offices. The far-famed *Picture Gallery*, containing many of the masterpieces of Rembrandt, Potter, Steen, Dow, Van de Velde, Ostade, Ruysdael, etc. Most popular of all is Paul Potter's "Bull." The beautiful *Park*, with the *Huis ten Bosch* (House in the Wood), a splendid Royal villa.

ELEVENTH DAY. SCHEVENINGEN: Old and New towns. The former a quaint fishing village. The latter a popular seaside resort.

TWELFTH DAY. DELFT: Pretty town, with clean canals bordered by lindens. Only a quarter of an hour by rail from The Hague. The *Oude Kerk*, with leaning tower. Here is a monument of *Van Tromp*. The *Nieuwe Kerk*, with magnificent monument of William of Orange. The *Stadhuis*, with some fine pictures.

THIRTEENTH DAY. SCHIEDAM and VLAARDINGEN: At Schiedam are 220 *distilleries*, where are manufactured the famous "Hollands" and "Geneva." Near by is the latter town, which is the chief depot of the wonderful industry called the "great fishery," in which a fleet of smacks is employed for the herring, cod, and haddock catch.

FOURTEENTH DAY. The tour concludes with return to Rotterdam, or to Hook of Holland or to Flushing, for England.

A Week's Extension. By extending the tour another week, time may thus be had for visiting Edam, Volendam, and Hoorn. If yet another week can be devoted to Holland, it might include Broek, Monnickendam, Purmerende, the wonderful Great Helder Dyke, Woerden, Arnhem, etc.

Fares. Travelling is unusually easy in Holland, the distances being so short. The average daily cost, including railway fare and hotel expenses, should not amount to more than from £1 to 23s. a day. This may be considerably reduced by avoiding the larger hotels and taking many meals at the cafés and restaurants. The fares from London to Rotterdam are: First class, single, £1 11s. 6d.; return, £2 8s. 3d.; Second class, single, £1 0s. 1d.; return, £1 11s. 7d.

Books. Abundance of literature of Dutch travel exists. Amongst the best works are: Meldrum's "Holland and the Hollanders;" Wood's "Through Holland;" Lovett's "Pictures from Holland;" Bird's "Land of Dykes and Windmills;" Hare's "Sketches in Holland;" Havard's "Picturesque Holland" and "The Heart of Holland;" and Esquiros' "Dutch at Home."

NORWAY

No country on earth can rival in its own special features the "Land of the Midnight Sun." Within forty hours we can reach that glorious coast, the Norwegian "Skjaergaard," which, for more than eight hundred miles, with its innumerable rocky islands stretches from Stavanger to the North Cape. Thus, by a short sea trip, we are able to penetrate one of the most romantic regions on the surface of the globe, where shining fjords, dotted with islets, ramify amongst precipitous mountains; where gleaming glaciers continue the snow-fields to the edge of the sea; where verdant and flowery fjelds are haunted by the bear, the elk, the lynx, and the reindeer; and where cascades dash down from dizzy heights to slumber in magnificent lakes that are counted by hundreds in this glorious territory. The attractions of Norway abound in every district. In this respect it is absolutely unique. It matters not whether the traveller chooses Telemarken, the Fille Fjeld, of the centre, the Dovre Fjeld, further north, the passage to the North Cape, the Western Fjords, or the region round Christiania.

A Week in Norway. Although it might be imagined that very little indeed could be seen of so vast a country as Norway, crowded with scenes of beauty, in the short period of a single week, yet on account of the easy accessibility of the sublime Western Fjords, it is possible for an active tourist to become well acquainted with a number of the most famous centres of that portion of the grand coast. If no longer time can be given, the week should be devoted to the neighbourhood of Bergen and the wonderful Hardanger Fjord. A day each should be given to Bergen, Odde, Eide, Vik, Vos, and Gudvangen. Thus, the lovely Sogne Fjord is also seen, and the week covers what is, in the view of many lovers of Norway, the most exquisite section of the country.

A FORTNIGHT IN NORWAY. FIRST DAY. BERGEN: The ancient painted warehouses in the suburb of *Sandviken*. The *Fish Market*. The grand view from *Fjeldveien*. The *Museum*, with wonderful antiquities of the Stone Age, the Bronze Age, the Early Iron Age, the Viking Age, and a magnificent Natural History Department.

SECOND DAY. ODDE: On a lovely branch of the Hardanger. Excursion to the *Buar brae Glacier*. The sublime *Folgefonde Glacier*.

THIRD DAY. EIDE: Lovely scenery all around. *Vossevangen*. The glorious drive to *Gudvangen*, commanding some of the sublimest mountain scenery in Norway.

FOURTH DAY. LAERDALSÖREN: Splendid scenery on the *Sogne Fjord*. Some of the waterfalls in the district between Gudvangen and Laerdalsören are 2,000 feet high, and one is upwards of 3,000 feet. The mountains flanking the fjord in this section are seldom less than 5,000 feet high. Nature here displays her wildest, grandest, and most marvellous moods.

FIFTH DAY. BALHOLM: A favourite centre for various little summer excursions amongst the superlatively beautiful mountain scenery, lake, valley, and fjord. This is one of the finest parts of the Sogne Fjord. The *Rommehesten* can be easily ascended, and from the summit a glorious view is obtained of glaciers and snowclad mountains.

SIXTH DAY. VADHEIM: On the lovely little Vadheim Fjord, an arm of the Sogne Fjord.

SEVENTH DAY. FÖRDE: Drive on to the lovely *Jolster Lake* and then to *Ordal* by the grand waterfall called the *Hulefoss*. Arrive at *Faleide*.

EIGHTH DAY. FALEIDE: One of Norway's choicest centres. The beauty of the scene defies description. Glaciers of *Olden* and *Loen*, and the Lakes *Langseter* and *Svingseter*, famous for fishing.

NINTH DAY. HELLESYLLT: Splendidly situated at the head of the Sunnelvs Fjord, which is a mile wide and extends for 20 miles between precipitous mountains 5,000 feet high.

TENTH DAY. Steamer along the grand and gloomy *Geiranger Fjord*, considered the most wonderful of all the Norwegian waterway gorges on the coast. The *Seven Sisters Waterfalls*.

ELEVENTH DAY. AALESUND The *Park*, with a splendid panorama. The centre of the codfishing district of Sonmor. Numerous cod-liver oil factories. Drive to *Borgund Church*, one of the curious wooden churches built in the 12th century.

TWELFTH DAY. MOLDE: Styled by some enthusiasts the "finest spot in all Norway." Romantically situated on the ocean at the entrance to the *Romsdals Fjord*. The lovely little park of *Reknaeshaugen*. Beautiful walk up to *Varden*, whence is seen one of the grandest of Norwegian panoramas.

THIRTEENTH DAY. From MOLDE to the wonderfully beautiful *Eikisdals Lake* by steamer. A delightful little excursion. Romantic gorges and glaciers.

FOURTEENTH DAY. Return to Bergen by steamer. Magnificent coast and island scenery. Some travellers prefer to do this voyage at night.

Three Weeks in Norway. Such a tour will, of course, afford fine opportunity of extended surveys of this marvellous land in the north. The visitor should go from Hull to Christiania instead of to Bergen, and cross the country from the eastern side, traversing the splendid mountain tract called the Fille Fjeld. This will occupy a week, for the ride is by carriole, the pretty little vehicle of the country, which holds one traveller, drawn by a sturdy little mountain pony. Doing 50 miles a day, always amidst glorious scenery, in a bracing atmosphere, with mountains, cascades, glaciers, pine forests, lakes, alternately in view, the distance of 300 miles is done in six days, and the tourist emerges from the sublime wilderness at Laerdalsören, at the head of the grand fjord mentioned already He will have enjoyed a week never to be forgotten. Then after the fortnight on the west already described, he can go from Molde north to Trondjem, spend two days there, then take the railway for Christiania, stopping at any few of the various attractive spots on the way for a day each.

A Month in Norway. This is an ideal experience. At Molde, after the three weeks already described, the tourist should undertake the journey by the romantic Romsdal, one of the loveliest valleys on earth, which leads to the Great Dovre Fjeld. This he will cross by way of Dombaas and Jerkin, going over the magnificent, wild, and sombre juniper plateau. The experience will be unique, and innermost Norway will be seen to perfection. The railway is reached at Lille Elvdal, and between that point and Christiania the fourth week may be spent delightfully at such favourite spots as the tourist may select, all being of enchanting beauty.

Travel and Expenses. The cost of touring in Norway averages £1 a day. The fare from Hull to Bergen is: First class. single, £4 10s. 0d., return £7; second class, single, £3; return, £4 10s. 0d. This is by the Wilson Line. The fare is somewhat less by the Bergenske Line from Newcastle.

Most of the travelling in the interior of Norway is by means of the two curious national vehicles. One of these is the pretty little carriole. The tourist himself drives, for there is only room for him on the seat of this enlarged kind of perambulator. Behind his seat, on a board, his luggage is strapped, and his box or portmanteau serves as a seat for the "skydsgut," or boy who accompanies him, though the companion is sometimes a "pige," or girl. This attendant is necessary in order to take back the vehicle after the change at the next posting station on the route. The whole traffic is organised by the Government, and the tariff is rigidly fixed. The other kind of vehicle is the "stolkjaere," a kind of two-wheeled dog-cart accommodating two passengers and the driver. For riding through Norway the best receptacle for luggage is a strong portmanteau, which should not exceed 34 in. in length, 16 in. in width, and 15 in. in height.

Books. The literature of Norwegian travel is to be studied with great advantage before going on a trip to this lovely land in the north. Among the books which should not be neglected are: Du Chaillu's great work in two volumes, "The Land of the Midnight Sun;" Lovett's "Pictures in Norway;" Wood's "Round about Norway;" Olivia M. Stone's "Norway in June;" Bradshaw's "Fjords and Fjelds;" and Lady Diana Beauclerk's "Summer and Winter in Norway."

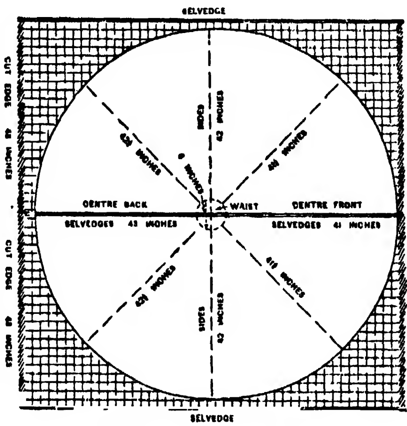
Continued

Full Skirts. Cutting on the Cross. Crossway Strips. Flounces. Stripes and Checks. Strappings. Velvet and Velveteen

By AZELINE LEWIS

A Sun-Ray Skirt. Though sun-ray skirts can now be bought ready-made for very little, it may be useful to know how to prepare one for pleating, and the next diagram [**69**] reveals the mystery.

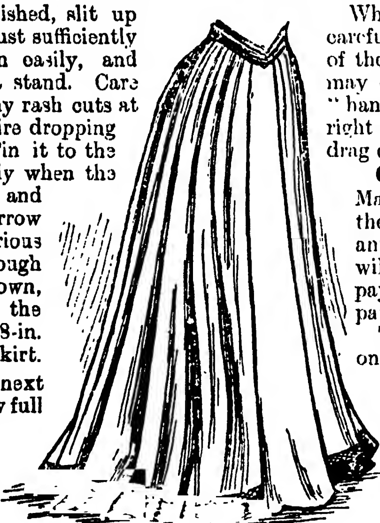
For this skirt two widths of 48-in. material are required, as with narrower goods it will not be possible to cut it with only two seams, and even with this width it will only just cut it in this way for a 40 or 41 in. front measure. With a seam back and front, for a tall person, the material would need to be 54 in. wide. The diagram shows how to cut the material, but the circle for the waist must *on no account* be touched till the skirt is pleated, which can be done at various places in London, and at many machine depots elsewhere.



69. A SUN-RAY SKIRT

The hem may be done before or after pleating; in the latter case the pleats will need pressing together when the skirt is hemmed. When pleated and the foot part finished, slit up the opening at the waist only just sufficiently to allow the skirt to slip on easily, and arrange it on the wearer or a stand. Care must be taken not to make any rash cuts at the waist, in case it may require dropping or raising at back or front. Pin it to the waist band, and sew on carefully when the skirt is removed; then hem up and neaten the opening. If narrow goods be used, join the various widths, till the whole is wide enough for the circle to be cut as shown, and remember to always snip the selvedges. 5¼ to 5½ yards. of 48-in. material are required for this skirt.

The Newest Skirts. The next sketch [**70**] shows one of the new full skirts with a panel front and wide side gores, the foot part edged with a band or shaped tuck of velvet cut to the same shape as this, and headed with silk passementerie.



70. THE FULL SKIRT

The method of cutting out from 48-in. material is shown in diagram **71**, the row of double broken lines indicating the direction to be taken if a trained skirt is desired. The quantity of material in either case is the same—that is, 4 to 4½ yards. This skirt is also unlined, the foot part being faced with lining cut to shape.

Diagram **72** shows another five-gored shape for the full skirt gathered at the waist. This is better suited to plain or thin materials than to checked or plaid goods; for these the circular form is best, as it allows the material to hang naturally, and there are no bias edges of the seams to interfere with the pattern. By increasing the slope of the gores, this shape can be made any width desired; in the diagram it measures 5½ yards at the foot part.

A bell-skirt, or jupe-cloche, is shown in the next diagram [**73**], and this, as will be easily seen, is but a modification of that shown in No. **71**, the cutting out of which would be carried out on the same lines. Pleated and yoke skirts are dealt with in TAILORING.

When cutting out a skirt, be careful not to slope off the corner of the waist-curve at back, as this may completely upset the fit and "hang," and, if pulled up to the right length, will probably make it drag or wrinkle across the front.

Cutting on the Cross. Material which has to be cut on the cross plays such an important part in dressmaking that it will be well for the student to pay particular attention to this paragraph.

Take the material, fold over one corner till it exactly meets the selvedge and forms a point in the opposite corner, as in the example marked A in diagram **74**. Mark off on each selvedge the width of the strip desired, fold or rule across carefully to each mark, and cut out, using up the corner pieces. Velvet or velveteen will need careful handling in order to avoid crushing the pile.

In the second example shown in **74**, marked B, we have the method of cutting on the cross when

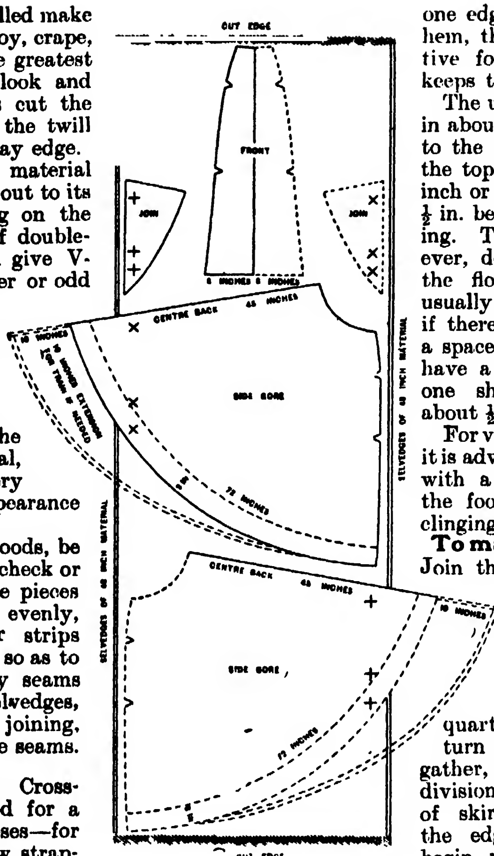
the material is of a twilled make like serge, frieze, corduroy, crape, etc., as it will make the greatest difference both in the look and set of the fold if it is cut the wrong way—*i.e.*, with the twill parallel with the crossway edge.

Remember that the material must always be opened out to its full width when cutting on the cross, or, in the case of double-width goods, it would give V-shaped strips. Any corner or odd pieces left from cutting out the garment can and should be utilised, as there ought not to be any waste; but these must be cut on the true cross and the right way of the material, or they will show very plainly and spoil the appearance of the fold.

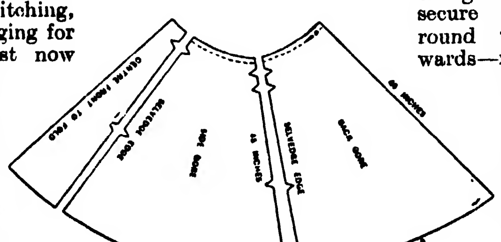
In the case of plaid goods, be careful to match the check or pattern. When all the pieces are cut out, join them evenly, using up the shorter strips among the longer ones, so as to avoid having too many seams together. Snip the selvedges, or cut them off before joining, then open and press the seams.

Crossway Strips. Crossway strips are required for a great variety of purposes—for binding, piping, narrow strappings, folds (either stitched or slip-stitched to the edges of revers, etc.), narrow ones for fancy yokes for faggot-stitching, also those used as an edging for crape folds; whilst just now there is a revival of the hand-made ornamentations of the Victorian era, both in velvet and silk, as well as "rouleaux," or rolls done over wadding, narrow quiltings, reversed pleatings, etc.

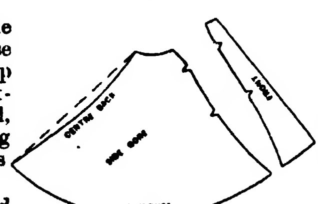
When cutting out crossway strips, allow good turnings, as it is not easy to get a perfectly even edge without, and the fold will set much better if these are fairly deep. A crossway strip has an unhappy knack of twisting; to obviate this, it is well, when making up, to fold along a good way to see that it is right before tacking or sewing.



71. CUTTING OUT THE FULL SKIRT



72. FIVE-GORED FULL SKIRT



73. BELL SKIRT

Flounces. Narrow gathered frills and flounces are usually of crossway material, finished off at one edge with a stitched or roll hem, the latter being very effective for thin materials, as it keeps the edge well out.

The upper one may be turned in about $\frac{3}{8}$ in. and gathered close to the fold, or over a cord, or the top may be turned in an inch or so, and gathered about $\frac{1}{2}$ in. below this to form a heading. The depth of this, however, depends on the width of the flounce, and a heading is usually only put to the top one if there are several. If there is a space between, each frill may have a heading, but if not, each one should overlap the other about $\frac{1}{2}$ in.

For very thin goods like muslin, it is advisable to put on the frills with a cording, as it prevents the foot part getting limp and clinging.

To make and put on Frills. Join the separate pieces into a circle—see that all are on the same side and are not twisted—press the seams open, hem the lower edge, divide and mark the halves, quarters, and also eighths, turn in the upper edge and gather, using one thread for each division. Mark the lower part of skirt to correspond, place the edge away from you, and begin with the bottom frill. Pin one division to a corresponding one of skirt, pin, draw up the gathers to fit the division, secure the gathering thread round the pin—point downwards—regulate them evenly, pin or tack in place, and proceed in the same way for each division. Remember not to put a join in the centre-front, and to keep the bottom frill even with the skirt edge.

When the half, or whole, of the frill is arranged in position, *sew* to the skirt and fasten off the gathering threads firmly on the wrong side. Proceed with the other frills in the same way. Crossway flounces are a little more troublesome than pleated ones, but are more advantageous, as they take less material.

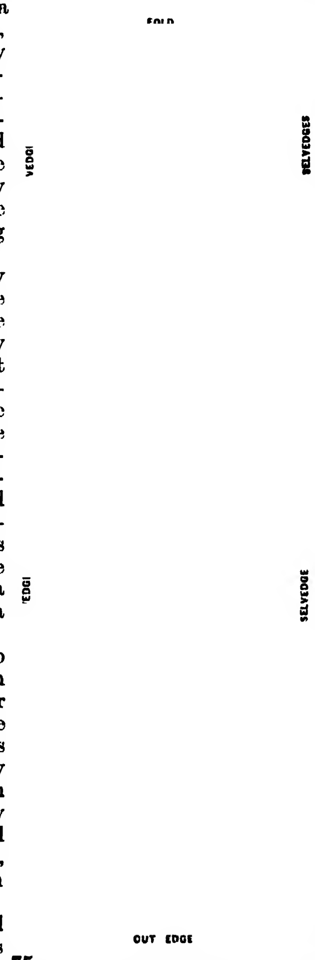
To put on pleated flounces, the same method can be followed, except that it may not be necessary to divide either skirt or

flounce into eighths. To find the quantity required, pleat up enough for a quarter of the skirt, measure and calculate from this. The quantities usually allowed have already been given. The joins must always come under a pleat, and the seam arranged to go in the centre-back, or in the least conspicuous position possible.

Stripes and Checks. An important, and sometimes very troublesome, part of dressmaking is in matching stripes and checks, particularly if the pattern be a large one. It is important, because the same material may be made up into either an extremely smart gown or the reverse, according to the arrangement of the plaid or stripes and the way it is cut, though the effort to produce the former may cause the cutter not a little tribulation of spirit in getting the design to match.

Plaids and checks are generally more effective if made up on the cross, certainly as far as the bodice is concerned, and very often this applies to the skirt also. For the latter, the two-piece shape like that of the striped skirt [diagram **64**] with the front seam on the cross, is perhaps the best; but the three-gore variety is sometimes used with great success. This, however, requires more material, as the side gores must match the fronts, and this may cut into a good deal of stuff if the plaid is a large one.

Diagram **75** shows how to place the various parts of a plain blouse on the cross; if tucked or gathered, pieces will have to be joined on the lower corners, as the joins must come where they will not be seen. This diagram is merely intended to show how the centre-back and front should be arranged to come on the cross, and also how to match these in the centre-fronts.



75. TO CUT A BLOUSE ON THE CROSS

With respect to stripes and checks, a point to remember is that they should all be arranged to slope towards the waist at back and front [diagram **37***f*], whilst for the skirt they should slope *outwards* from the waist to the hem. The slope, however, should be a gentle and not an abrupt one, as the latter would have a broadening effect and the former quite the reverse.

These rules also apply to the perpendicular arrangements of trimming on bodice and skirt, and should always be borne in mind when making or designing for stout figures.

Be very careful to match the line of the checks in folds, crossway bands, or flounces, or anything of the kind used for trimmings, or there will be a succession of broken lines, which will much detract from the harmony of the gown. For the fronts of a bodice or coat also the pattern must be very carefully matched.

Strappings and Folds. Strappings may be cut on the cross (if for seams), and straight or moderately curved designs; but where these are of any definite shape or curve (as in the front foot part of the striped two-piece skirt) they must be cut to that shape, and to fit the garment they are to ornament. This matter, however, is fully dealt with in TAILORING.

The narrow shaped tucks which are often arranged on the foot part of a skirt in a group, one overlapping the other, are cut from the skirt-edge to get the right curve [diagram **76**]. If the material be somewhat thick, these may be lined, the edges of material and lining being turned in to face, and machine-stitched. They are, however, usually unlined, and have the edges turned up and stitched. Be careful neither to stretch the lower edge when turning up, nor the upper one when putting on.

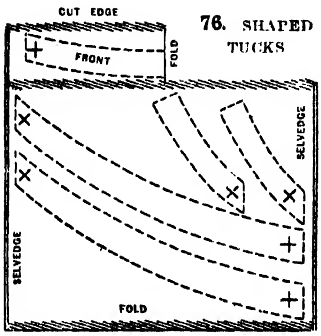
Piping must always be made of crossway material, and when sewing on, particularly if to go round a curved edge, the cording should only be held tightly enough to keep to the shape, and not pucker the material. A pointed bodice looks best with the waist part finished off with piping, but it requires much care and practice to put this on well. The point will require particular attention to keep it sharp, and when turning over to cut away correctly the superfluous parts.

When working round curves the raw edges of the piping should be snipped at the points between the rounded portions to allow it to set quite flat.

Shaped Flounces. The shaped, or godet, flounce is now used for ornamental purposes, or as a foundation for narrow frills for a trained or other skirt of thin material, to its great improvement in look and hang.

For this we must turn to diagram **77**. Measure the bottom of the skirt, then draw a line two-thirds of this (this allows something for fulling on slightly; it can be a little less if the material be rather thick), mark the centre, also the tape for the half-length of line just made, and pivot from this for the inner curve with chalk or pencil.

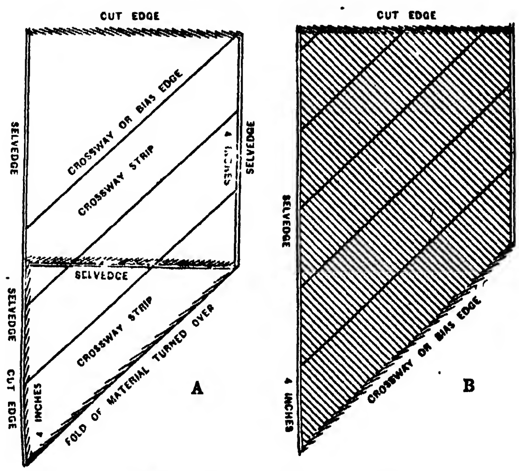
Mark off from the half circle thus drawn the depth of flounce required, and draw the outer circle as shown in A of the diagram, the



76. SHAPED TUCKS

broken line indicating how to alter if we wish to make it deeper at back and sides. A more circular arrangement is shown in B, suited to thin goods, when a full, frilly effect is required. C is also obtained from the same drafting by reducing the outer curve and making it less full. D shows the spiral frill, sometimes used for capes or where required to go round a shaped edge. E and F are a collar and cuff, which are given as further examples of the application of the circular shape.

From these we think the worker will see how to get any other variation she may be called upon to make, remembering that, where fulness at the lower edge only is needed, it will be cut on the principle shown; the greater the fulness at the lower part, the more complete must be the circle, and vice versa.



74. CUTTING ON THE CROSS

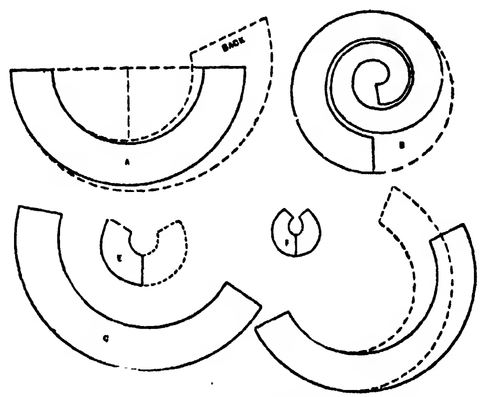
When cutting the upper part of skirt, allow for the depth of flounce, with an inch or two extra, as such skirts require to be cut fully an inch or two longer than a plain one.

Velvet. Materials with a pile, like velvet and velveteen, require very careful manipulation both in cutting and making—firstly, in order to get the right way up of the material, and, secondly, because every tack and pin mark will show.

The closely fitting style is usually adopted for these materials, either as a plain bodice and skirt or a princess gown; but either must be faultless in cut and fit, and should not be attempted by any but an experienced worker. The bodice and sleeve linings should be absolutely perfect as to fit before arranging or cutting the velvet. To find the right way up of the velvet, let the worker hold it in front of her and look down it; if a whitish sheen appears, reverse it and then cut. This is most important, as if cut the wrong way it will lose the rich, soft look which is its characteristic beauty. Remember, too, that each piece must be cut separately, and to face, as shown in diagram 27.

To press velvet, velveteen, and other pile goods, fix the iron face upwards, or let it be held in this position, then take hold of the end of the seam and pass it lightly over the iron, which should not be too hot. For long seams the better way is to secure one end, whilst the worker holds the other and passes the iron lightly along the portion to be ironed; but on no account must velvet be pressed on a flat surface. Be very careful not to crush the pile, or to hold the seams where the finger-marks will show.

Velvet also requires great care in putting together, as the two edges, owing to the pile, are very liable to slip from each other out of position; whilst the utmost care must be taken with pinning or tacking to make no marks that will show, and also to hold it lightly when working. Steel pins should always be used for velvet work; and silk instead of cotton for basting.



77. CIRCULAR FLOUNCE

Continued

HOW THE BLOOD RECEIVES FOOD

The Blood as an Agent of Nutrition. Digestible and Indigestible Foods. Effects of Starvation and Excess of Nutriment

Continued from page 677

By Dr. A. T. SCHOFIELD

Assimilation of Food. We have in detail traced the progress of the sandwich—our typical food—from the time it entered the mouth as meat, salt, bread and fat, until it reached the heart by two channels—the meat as purified peptones, and the bread as a special form of sugar arriving by the *inferior vena cava* from the liver; the salts dissolved in the mouth, and the fats from the lacteals of the lymphatic system, divided into microscopic drops of oil, reaching the heart by the *superior vena cava.*

Of the circulatory system which the food has now entered we shall speak in detail later. We only allude to it now as the vehicle by which our food is distributed round the body to the various cells. We speak of *assimilation* now because it continues the story of digestion to the end, but it will be even better understood if the chapters on circulation are read first. Enough, however, will be explained to make the process intelligible without this.

In the fat, the meat, and the bread, we have all the solid food the body requires, now converted into liquid and brought into the blood. But there is besides a liquid and a gaseous food. We will suppose, then, that besides the sandwich being eaten, the thirst has been quenched by some appropriate fluid which has entered and sufficiently diluted the blood, and likewise that the traveller has, during the eating and the drinking been breathing the fresh air. The oxygen he has thus received also enters the blood before it finally leaves the heart. Let us just look, then, at the blood stream from a nutritive standpoint as it passes through the great artery, the aorta, for distribution all over the body.

The Blood as an Agent of Nutrition. We notice in the first place that it is bright scarlet, owing to all the little discs or corpuscles with which the stream is laden being now full of fresh oxygen on their way to the body. The fluid part of the blood, we know, is laden with peptones, sugar, oil, and water, so that we see this curious anomaly, that the solids in the food are conveyed in the fluid of the blood, and the fluid or gaseous food is conveyed in the solids of the blood to the tissues. As this very blood will have returned to the heart again in little more than a minute, the process of assimilation which we are about to describe takes place at lightning speed.

Until the blood reaches the capillaries, which form an intricate network in every part of the flesh, not a single drop of nutriment passes out. The walls of the arteries, three in number, are far too thick and strong to permit of this, but in the capillaries the conditions change in several ways. Though practically innumerable, they are so minute that sometimes they will only allow a single corpuscle to pass through at a time. In the blood-vessels the size is fairly fixed and constant, in the capillaries it varies greatly; sometimes these are closed altogether, sometimes they are stretched to four times their natural size. This sudden subdivision of the stream into hundreds of tiny channels brings the speed of the flow down from a foot a second to an inch a minute.

The next point is that the capillaries have only one thin wall composed of living cells, which often opens a little, and lets some of the blood out to the hungry body cells that press round it on every side.

The Blood and the Cells. We picture, then, the blood, laden with nourishment, arriving freshly at the capillary every minute and then slowly passing along it. During its passage all the spare oxygen is taken out of the corpuscles and passes across the thin walls into the cells, enabling them to breathe. The cells, on their part, return their carbonic acid gas into the liquid part of the blood, the result of the interchange being that the colour of the blood is altered from a bright scarlet to a dull purple. Then the liquid food is rapidly seized by the cells as it passes through the thin walls, and is replaced by their refuse, which partly passes into the blood in the capillary, and partly into the lymphatic channels that everywhere surround this blood-vessel.

The blood, therefore, as it leaves the capillaries and enters the veins on its way back to the heart has lost all its food, and is of no use to the body, until it is returned to the heart to be replenished.

The cells, supplied freely every minute with fresh food and air, are kept in healthy life. This is as it should be, but the reality is often very different, as will be shown when we speak of starvation. The blood courses round, but empty of nourishment, or stored, it may be, with alcohol or drugs. If we consider well the state of the cells, which are absolutely dependent for their very existence on what we choose to put into our blood, the eating of good and sufficient food will soon take the form of a moral obligation.

Cells in Revolt. Fortunately, if treated badly, the body cells have means of making their wants known, and, if their messages are neglected, of retaliation.

In the first place, if there is too little fluid in the blood, they produce a painful feeling at the back of the throat, which we call *thirst.* To relieve this it is necessary to introduce

more fluid into the blood. It does not matter whether the fluid be injected into a vein or supplied through the skin by wet sheets, the thirst goes, just as much as if the fluid were drunk.

If there is deficiency of air the message is sent to the lungs and stimulates them to action by a feeling of *breathlessness*. In anæmia, for instance, where there is a deficiency of these red corpuscles, there is a constant feeling of breathlessness. It is not the lungs, but the cells that cannot breathe. In the third place, if there is no food in the blood a sinking is felt at the "pit of the stomach" which we call *hunger*.

If, then, these warnings are neglected, the cells soon cease to do their work well, and the whole body suffers The mind and brain get tired as well as the body, and it is well if worse symptoms do not supervene.

Indigestible Foods. We have spoken so far of the sandwich as if it were all digested. Such, however, is not the case.

The following table gives the digestibility of proteids in meat, carbohydrates in starch, and hydrocarbons in fat; and from this table we shall see that our sandwich is by no means all assimilated.

Both these tables show how very much more wasteful brown bread is than white, and how much less vegetable albumen (proteid) is digested than animal albumen. The subject may be presented from one more point of view in a table still simpler:

DIGESTIBILITY OF ANIMAL AND VEGETABLE FOOD.

ANIMAL.		VEGETABLE.		VARIETIES OF FOODSTUFFS.
Digested.	Not Digested.	Digested.	Not Digested.	
Per cent.	Per cent.	Per cent.	Per cent.	
90	10	75	25	Per cent. total solids.
81·2	18·8	46·6	53·4	" proteids.
97	3·0	90	10	" carbohydrates and hydrocarbons.

This table shows that in meats 10 per cent. of the solids are not digested; in vegetables 25 per cent.; that in meat above one-sixth of proteids is undigested; in vegetables more than one-half; that in meats 3 per cent. of the fats, etc., are undigested; in vegetables 10 per cent. These figures need occasion no surprise when we reflect that the meat comes from animals

EXAMPLES OF THE DIGESTIBILITY OF VARIOUS FORMS OF FOOD

DIGESTIBILITY OF PROTEIDS IN		DIGESTIBILITY OF CARBOHYDRATES IN		DIGESTIBILITY OF HYDROCARBONS IN	
Meat	Nearly all	Sugar	All	Butter	98 Per cent.
Fish	"	White bread	99 Per cent.	Margarine	96 "
Milk	95 Per cent.	Indian meal	97 "	Milk	96 "
White bread	90 "	Peas	96 "	Fat bacon	93 "
Indian meal	89 "	Brown bread	94 "	Fat meat	86 "
Brown bread	87 "	Potatoes	92 "		
Peas	86 "				
Potatoes	84 "				

From this point of view potatoes and fat meat are the most wasteful foods.

Let us look at the matter from another standpoint, for it is one which is little understood or written about, and concerning which reliable information is not always easy to obtain.

We have given the percentage of foodstuffs absorbed in different articles of diet. The following table, based on other experimental data, gives the amounts of food unabsorbed from certain articles of diet, and passed out of the body:

UNABSORBED FOODSTUFFS IN	PROTEIDS.	CARBOHYDRATES.	HYDROCARBONS.
	Per cent.	Per cent.	Per cent.
Animal food:			
Milk	7	5	—
Fats	—	12·7	—
Meat	2·5	—	—
Vegetable foods:			
Maize	15·5	17·5	3·2
Peas	27·8	—	7·0
White bread	18·18	·5·7	1·2
Brown bread	30·0	—	7·4
Black bread	32·0	—	10·9
Rice	20·4	7·1	·9
Potatoes	32·2	3·7	7·6

that, feeding on vegetables, have already themselves rejected what cannot be turned into flesh. Our loss in meat foods, therefore, must be less than in vegetables, where we have to do all the sorting ourselves.

In our examination of the undigested materials in various articles of food (the last we shall refer to), it was found that of meat, eggs, bread, rice, macaroni, the excreta contained about 5 per cent. of the amount taken; of milk, peas, and potatoes nearly 10 per cent.; of black bread, 15 per cent. These different results do not exactly agree, but altogether they are of considerable practical value, as has been pointed out.

Starvation. Turning now to deficiency of food, in *starvation* we get loss of weight, loss of heat, various symptoms, and death. Death, as a rule, occurs in animals when the body has lost two-fifths of its weight.

The fat disappears very soon, that in the orbit being used up first. The blood loses in water three-fourths of its weight; the pancreas and liver more than half, the muscles and stomach about two-fifths (40 per cent.), the skin and kidneys one-third, the bones about one-sixth; while the nervous system remains almost unchanged in weight, losing only 2 per cent.

The heat of the body varies at first four or six degrees, and then shortly before death (when the fat stores are exhausted) falls rapidly down to about 30° C. at death. In starvation death occurs rather from the loss of heat than from the loss of nutrition. This is easily understood when we remember that nine-tenths of our 3·400 foot-tons of daily food force are used to produce heat. Hence artificial heat will delay death for some time.

The principal symptoms of starvation are hunger, thirst, pain, sleeplessness, weakness, and delirium or stupor.

Death generally occurs in a little over a week after the stoppage of all foods, liquid and solid. There is no case known where life has been prolonged for weeks after such stoppage. As we have lately seen in England, however, only a very small quantity of food and water are required to prolong life considerably.

Excess of Food. Excess of food in the infant is got rid of generally by vomiting; in the adult more generally by the bowels. Before this riddance takes place, however, as much as possible has been digested and absorbed; and the surplus only that cannot be dealt with is thus ejected. The amount absorbed may, however, be greatly in excess of the needs of the body, or even of its storage power. We will see how each variety is dealt with.

Minerals. Excess in salts is not often now met with, though formerly it used to be very common on long sea voyages. Where it occurs, intense thirst and skin eruptions of every sort —scurvy, etc.—are the results.

Excess of Fluid is easily carried off by the kidneys up to a certain extent, but if continued it dilutes the blood, impoverishes the tissues, and weakens the digestive organs.

Excess of Alcohol at first paralyses various parts of the nervous system, and by irritation of the tissues afterwards causes great overgrowth of the connective tissues, leading to many serious diseases.

Excess of Proteids. The term "luxus consumption," used in various senses in different text-books, is by some intended to mean the direct combination in the blood of an excess of proteids beyond what are needed for building up the tissues; but the term is not of much use, since to a certain extent this combination always takes place. As an excess of nitrogenous diet is very common amongst all who can afford it, it becomes a question of great importance how it is disposed of. If very excessive, part may not be digested at all, and be excreted directly.

That which is peptonised, if in excess, may be still further changed by the pancreatic juice into leucin and tyrosin, which may pass out as urea by the kidneys. Much that is not so changed becomes *uric acid*, and lays the foundation for gout, gravel, and stone. That which can be used is stored in the blood as *serum albumen*, and some perhaps in the spleen.

Excess of Carbohydrates. These are stored in the liver as glycogen, and the excess is also largely stored in the tissues as fat. Excess can be got rid of by the kidneys as sugar. Great dyspepsia results from excess of carbohydrates.

Excess of Fat. This is stored to almost any extent in the tissues, and eventually in the muscles and various organs, causing after a time great degeneration of the tissues, and of such organs as the heart. It must not be supposed, however, that the body fat is derived solely from fat food. On the contrary, it was found in fattening a pig that 472 units of fat were stored for every 100 units of fat given. Fat is largely formed from carbohydrates and also from proteids.

Effects of Deficiency or Excess. Speaking of the general effects of malnutrition and excessive food, it might be said that, on the whole, both are well borne if the organs are sound and the general habits hygienic and regular. There are men and women, two and three stones under their weight, leading active and healthy lives, though, of course, at considerable risk. On the other hand, there are men and women three and four stones over their proper weights who complain of nothing.

It is perhaps in adolescence that these irregularities have their worst effects. If a boy or girl is a stone under his or her weight, and is growing rapidly, any hard study is sure to be fraught with bad consequences. Of all this we shall speak in detail in the Health section. [See Health.]

We now leave the subject of digestion and food, as far as its physiology is concerned, with the hope that a careful perusal of these three chapters has left a clear impression, and that the whole digestive process can be seen as in a map. Fig. 38 should especially be studied until the general course of the food is thoroughly understood.

Continued

ART SCHOOLS AND OIL PAINTING

Training. The Great Schools. South Kensington. The Royal Academy. The Paris System. The Best Colours. Colours to be Avoided

By P. G. KONODY and HALDANE MACFALL

We now come to the very serious question of where the student may get the best artistic training. Theories as to training are so hotly opposed to each other that it is perhaps as well to say a word upon the subject, and then to guide him to some of the best schools.

The Two Schools. At the start the student will be assailed by the claims of the two extreme schools. There is the school that would have the student create the masterpiece at once, learning drawing—the grammar of art—in the doing. On the other hand is the school that deliberately crushes out all personal statement and inclination in the student, until his hand has become the slave of academic precision, the slave of rule and precedent. Now, the free school, whilst it has turned out men such as Manet and Delacroix and Millet, more often turns out a stumbling mediocre artist who is never master of his tools, who speaks his art haltingly. At the same time, the academic school. whilst it turns out men of great skill, like Bouguereau and Lefebvre and Cabanal—men of great precision—rarely produces a genius; they are learned men in the arts, masters of craft, without any powers beyond craftsmanship.

The student is wisest who strikes the middle course. He must master the craftsmanship of his art, for until he is its master it will be forever mastering him; but let him look to it always as only the means to an end, never let him mistake it for the end in itself.

Let us take a poet. The boy cannot burst into the great statement of poetry; if he would write poetry in verse, or the still more profound and subtle style of prose, he must first master his grammar—the rhythm of verse and the law of rhyme. What will it avail him to have ideas and imagination and fancy if he know not how to utter them?

If the student cannot draw a foot or a head with a piece of charcoal, if he cannot deftly paint a bottle and a sliced lemon, how is he to portray all the subtle beauties of the human figure? His imagination may teem with a sense of the emotions of life, but who will find it in halting colour and incloquent line? How shall a musician utter music if he is not sure of his notes? It is the first and vital business of an artist to be able to draw with facility. In which schools may he best learn his trade?

Training in England. England labours under one grave disadvantage in relation to art education in comparison with France; she has nothing like the same enthusiasm amongst the men who have attained fame. There is, of course, a great waste of artistic enthusiasm and effort in Paris, but that is at least better than indifference.

The French schools teach from the plaster cast as long as it helps towards the drawing and painting from the life; the English schools make the antique almost an end in itself. The French student is aching to express something; the English student thinks that when he is through the schools the ideas will come to him just as patients come to the qualified doctor. From the French students' point of view, nothing matters in heaven or on earth except art.

The Grammar of Art. A man is safer in learning the grammar of his art in his own country, for he learns to speak his own tongue. The actual teaching is finest perhaps in Paris, but the danger of falling into ridiculous mannerisms is far greater. If the student, then, would learn his craftsmanship in England—mark you, his *craftsmanship*, for no man may learn to create works of art in any school—he has an excellent and marvellously cheap school in every important town throughout the kingdom, in connection with the great Government Art School at South Kensington. The schooling is very good. He may learn, then, the art of the designer, of the painter, or the sculptor. He will, if employed by day, be able to attend night classes. He will, above all, have the inestimable advantage at these schools of being in constant touch with the great fact that the craft of art is not confined to the painting of the easel picture, but extends to a hundred industries: in other words, that there is an immense and a most profitable field open to craftsmanship and artistic invention. And he will be constantly reminded that Holbein and Michael Angelo, Raphael, and Dürer and Leonardo da Vinci put as much delight into the decoration of a cabinet or a wall as into a picture or a statue.

The Great Art Schools. From his studentship at the South Kensington schools, he should emerge facile in his drawing and well fitted to proceed to the painting from the model, draped or undraped, either in those or, better still, in the Royal Academy schools. He is thus saved the tedious preliminary training from the antique, which should be mastered beforehand, and so free to give all his strength to his schooling in paint at the great centre, where his pupilage gives him special privileges when he comes to exhibiting his creative work.

If the Royal Academy schools are difficult of access to him, or if the South Kensington schools gall him with an overdose of technique, he still has excellent schools in London, where a more enthusiastic and keener art atmosphere prevails, such as the Slade, or the private art schools under the direction of well-known artists.

Indeed, it is at this stage—when, having mastered facility in drawing, he proceeds eagerly to painting—that his enthusiasm requires the encouragement of keen fellow-students and the counsel of his masters. But it is precisely at this very stage that the English academic schools are inclined to chill him; it is precisely at this stage that the Paris system urges him forward. The question, therefore, now becomes of vast significance, whether he shall go to Paris or to London.

Photo by] [*Alinari*

THE VIRGIN AND CHILD, WITH ANGELS, BY BOTTICELLI (UFFIZI, FLORENCE)

A striking instance of space composition, solving the problem of placing a group in a circle

Royal Academy Schools. These schools are visited in rotation by Academicians—in theory by each, but in practice as often as not by the less important men. The system has the advantage of preventing staleness of teaching; it also has the disadvantage that the students never get the enthusiastic attitude of pupilage towards their chosen master that they have in Paris. The training at the Royal Academy schools is absolutely free, whilst its prizes are generous and its scholarships handsome.

The highly stippled and finished drawing from the antique that took months to do—the bane and curse of the English schools—has gone out of fashion; but there is still far too much time spent upon these elaborations, and the student would do well to draw frequent casts instead of spending too much time upon a few. However, the student, if he have the will, may soon push on through the antique to the painting schools of the Royal Academy, where he will work in the company of students from amongst whom will be elected most of the future Associates and Academicians, and from his fellow-students he will learn more than from his masters.

It is a serious question whether he will not get as good schooling at the Slade or at the studios of well-known artists. But, in any case, even should he so decide, he will find the fees reasonable—indeed, the art student is not often a well-to-do person. Certainly he will find outside the Academy a keener feeling for and sympathy with the art of his day than in the drowsier shades of the Academy schools. Their very existence is

a protest against hidebound convention in training. They have no precedents of long-established years to live up to; they have no prestige of academic culture to maintain; they do not reverence age or the past because these things are of the dead, but solely glorify the splendour of good work. They go for the breadth of things rather than for their detail. And whilst they realise that *facility* in craftsmanship makes for style, they do not allow this to be mistaken for slovenliness or inaccuracy.

The Dangers of Training in Foreign Schools. Now a warning note before we go to Paris. Art in a nation must come from within; it cannot be imported, like merchandise, from without. Rome under the Cæsars, like Paris under Napoleon, had foreign art treasures poured into the city, but it created no artistic revival amongst the people. The student who goes to Paris, or anywhere else abroad, can only learn to become a good workman; he must not try to content himself with a triumph in the artistic manner of France, for it is but uttering a foreign speech—he can but become a trickster and a copyist. But schooling in workmanship he will get in Paris such as he cannot find elsewhere in the world. To begin his art training in France is to make a mere French imitation of an artist. Nothing is easier to pick up than the tricks of a Degas or a Monet or a Corot. The danger lies in his trying to paint a smart picture for the exhibition rather than to achieve an emotional statement of life as he himself sees it. Let us put aside the dangers of the academies on the one side and of foreign tricks and fashions on the other, and imagine the student simply bent on acquiring mastery and facility in the use of his tools.

He goes to Paris. He is at once in a new atmosphere—an atmosphere in which art seems to be a vital thing, a need of life. The studios are cheap. They are open to him if he but have the very small fees to pay his way and the energy to stick to his work. He sees the *masseur*, or head student; pays his fees; and, with his easel and chair, enters the studio. He goes through the tomfooleries of initiation, finds friends amongst his countrymen, and a dozen good comrades amongst the French students to cheer him on.

The Art Student in Paris. At Julian's he pays about £1 a month for the half-day (8 to 12 o'clock), or 33s. a month for the full day (8 to 12 and 2 to 5 o'clock). At Carlorossi's he will find a cheap night school; at Delacluse's an afternoon costume class. And a dozen other studios are available. If he prefer it, he can split his time between them.

But, mark this, he will find the gay and debonair French student, who skylarks between his working hours, who plays the harmless fool on the boulevard and at the café in the evening, to be a grim and serious hard worker whilst the model sits. He will find the French student standing at the studio doors before they open in the early morning; from the moment the model takes the pose the French student works with all his hand and heart and soul. He works in no dutiful scholastic spirit, but with all his might, to master technique. And even when he takes his leisure at the students' cafés, or in his walks abroad, his whole aim and talk is art. He cares little what Government is in, or what horse is likely to win the French Derby; for him there is but one mighty interest in the universe, and that is art. The result is a technical accomplishment that is a marvel. There are loafers and idlers, but they stay outside the schools.

And the whole atmosphere of the schools is in keeping with this artistic enthusiasm. At regular intervals there are trials of strength in skill between the students; then the winners compete for the supreme place and the privileges of the studio. The students have choice of place before the model as the result of these "concours." At every hand is strenuous, wholesome, artistic rivalry. At every turn is the word of praise or blame from fellow-students. And the very summer holidays are spent in the country painting.

The Luxembourg Galleries. There is the superb collection of modern art in the Luxembourg Galleries to educate the student in the picked examples of modern masters. The studios are visited by the first artists of France without thought of remuneration. Men of the rank of Sargent give a day or two days of their precious week to the youngsters. And however much their views on art vary, in craft they all say the same thing, teach the same lesson—"Search out form and colour; search and search and search."

The French student has good schools; he has enthusiasm for art; he lives in an atmosphere of enthusiasm. He has at his side not only the superb collection of old masters that has made the Louvre the talk of the world, but he has in the Luxembourg the splendid examples of the moderns purchased by the State. Here you may see John Sargent or Whistler, or Watts or Manet, or Steinlen or Degas; each at his best. The whole attitude of his masters is modern. He works in the spirit of his age.

Art in Rome is dead—the once famous home of the art student is wholly gone; its schools have passed to Paris. In Germany there are good schools, and cheap, especially in Munich and Düsseldorf, though few to rival Paris. There is nothing the student can learn in Germany that he cannot learn equally well or better in Paris, where he lives, moreover, in a far more artistic atmosphere.

The Americans, in spite of their superb school, the Art Students' League of New York, flock to Paris. The great system of the past, the apprenticeship of students to artists, shows signs of revival in America, the most astute of all nations, and still holds everywhere in sculpture.

PAINTING IN OILS

The art student should always remember that to a painter the quality of his colours is of vital importance. Many colours used with perfect confidence a few years ago have turned out to be utter trash; indeed, in water-colour,

Group 1 AGRICULTURE 6 Continued from page 638

THE PLANTS OF THE FARM

Grain Crops: Wheat, Oats, Barley, etc. Habits of Various Kinds of Grasses. Weeds that Destroy Crops. Seeding Tables

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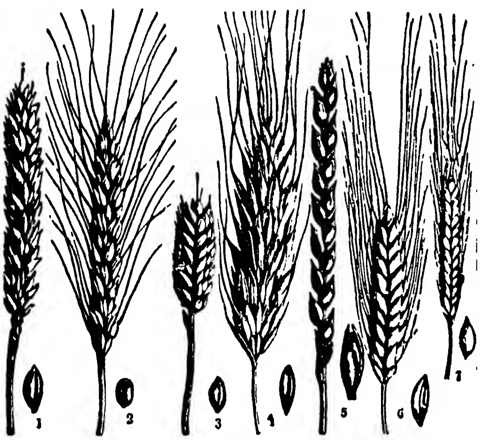
Wheat. In considering the plants of the farm we may deal first with the cereals, or grain crop (natural order *Gramineæ*). Wheat is a fibrous and deeply-rooted plant (genus *Triticum*), especially suitable for cultivation on the heavier soils, although the best grain is produced on soils of rich character, such as the alluvial. Winter wheat, which is chiefly grown in this country, is much longer in the ground than either barley or oats, the period of growth continuing from October,



WHEAT

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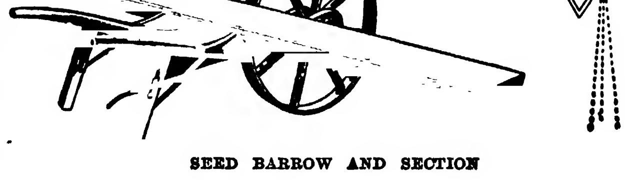

SEED BARROW AND SECTION

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Barley is commonly grown after swedes or turnips, or after certain forage crops, that have been eaten off light land by sheep, which were simultaneously fed with rich foods, such as linseed and cotton cakes, grain, and hay. In this way the soil, often thin or of light texture, is enriched by the manure dropped by the flock, and a good crop of grain ensured. Barley is a shallow-rooted plant, hence its adaptability to chalky and other light soils. It may be manured, like oats and wheat, with the artificials which provide phosphates and nitrogen, but nitrate of soda must be sparingly used, inasmuch as it may depreciate the quality of the grain. Manures are seldom necessary where barley is taken on land upon which sheep have been well fed

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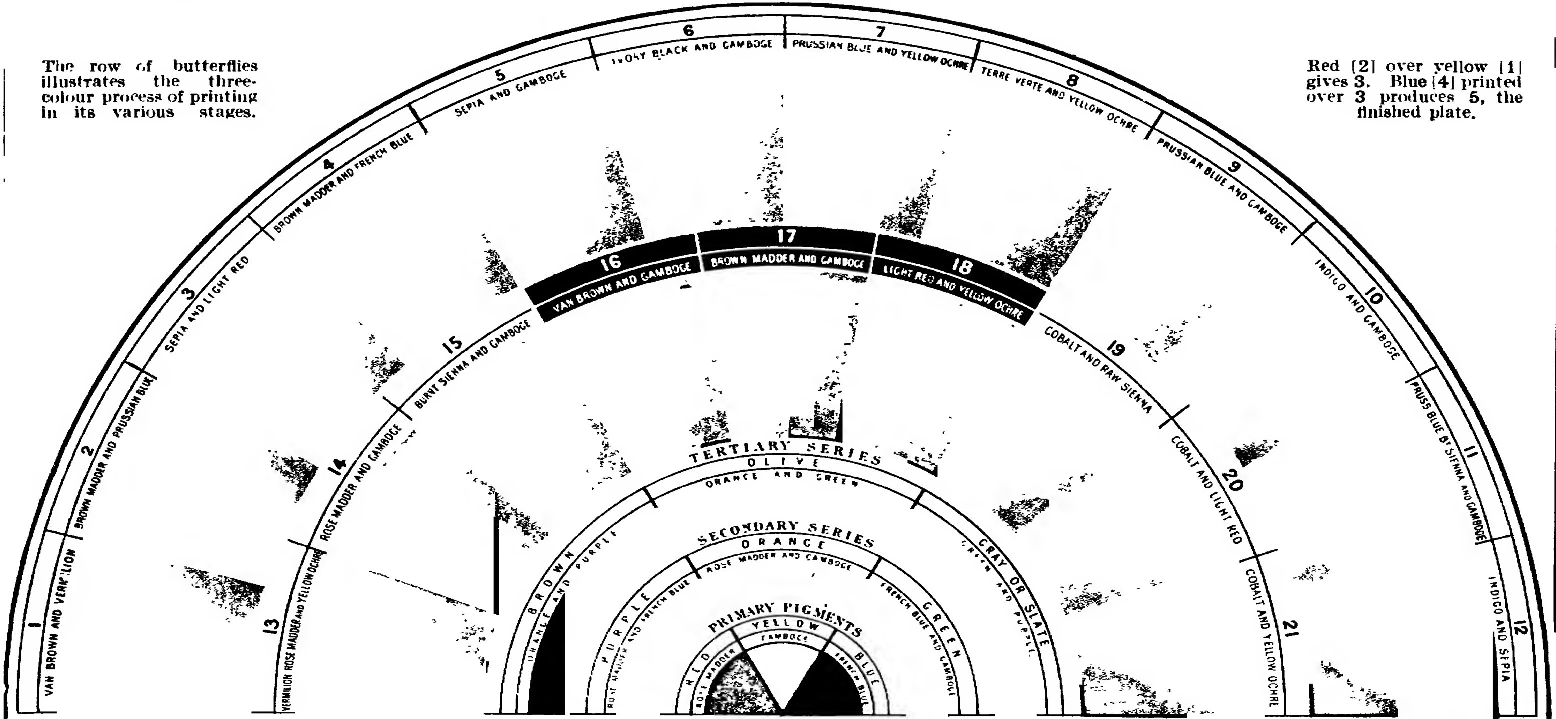
THE COMMON OAT
[Avena sativa]

1. Yellow [First printing] | 2. Red | 3. Yellow and Red [Second printing] | 4. Blue | 5. Yellow, Red, and Blue [Third printing]

The row of butterflies illustrates the three-colour process of printing in its various stages.

Red [2] over yellow [1] gives 3. Blue [4] printed over 3 produces 5, the finished plate.



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A COLOUR INDICATOR, WITH EXAMPLE OF THREE-COLOUR PRINTING

[By Frederick Oughton

The Indicator is divided into three equal angles, each having for base one of the Primary Pigments. Tints 1 to 4 are for Backgrounds, Mountains, etc. Nos. 5 to 12 for Flowers, Foliage, etc. Nos. 13 and 18 for **Flesh.** Nos. 1 and 19 for Shadows in Flesh, etc. Nos. 14 to 17 Fruit, Flowers etc. Nos. 20 and 21 Gray Tints for Clouds and Distance. Sixteen Colours are used in mixing the Tints—*viz.*, Vandyke Brown, Sepia, Brown Madder, Burnt Sienna, Raw Sienna, Ivory Black, Terre Verte, Prussian Blue, French Blue, [illegible]

Turner even tried tobacco-juice. The student may be certain that it is best to go to good colour-makers, for the less reputable dealers only adulterate their cheaper substitutes, and call them by the same name.

Colours. The student should first of all be sure that his colours are good, and in the second place he should remember that, even being good, the fewer he uses the less chemical action is likely to arise through their intermixture.

Before setting the palette, let us see which are safe colours to use and which should be avoided. The most important pigment on the palette is white, for white is used throughout his painting to lighten the tones. And though flake-white is whitelead, and acts disastrously on all vegetable colours, on the other hand, it has a binding and preservative effect on earth colours. Several substitutes have been tried, but *flake-white* remains supreme.

Of the yellows, the pale *lemon yellow* (baryte yellow) is quite safe. The *cadmium yellows* (pale, middle, and orange) are good sound colours which have quite superseded the utterly bad *chrome yellows*. There is a very beautiful and luminous yellow called *Aureoline* (or cobalt yellow), which is permanent. The chromes are as bad in oils as was the *gamboge* of the old paint-boxes in water-colours—a wretched colour that goes green and sickly, and, being of vegetable origin, is destroyed by the whitelead which is used throughout oil painting. *Indian yellow* is also not to be recommended. *Yellow ochre* is of vast value on the palette, and one of the most essential of colours.

Essential Colours. Of the greens, apart from those made through an admixture of yellow and blue, two or three are very necessary. There are two beautiful and absolutely permanent colours that should be on the palette—*Viridian* (the transparent oxide of chromium, which has an emerald hue), and the opaque *oxide of chromium.* Oil painters often use the old and useful *terre verte*, a permanent ochre. These three colours save the artist from many dangers in mixing yellows and blues. The chrome greens are vicious colours, and are not to be confused with the fine oxides of chromium. Indeed, all the other greens are best avoided.

Of the blues, the very expensive and splendid *ultramarine* (or lapis lazuli) is well replaced by *French ultramarine* (or, as it is sometimes called, "permanent blue"), a permanent and very beautiful dark, vivid blue; whilst *cobalt*, one of the safest and tenderest of blues, should be on every palette. It is best to have no other blue, and especially to avoid the *Prussian* and *Antwerp* blues.

If a purple be required, *purple madder* is the safest.

Of the reds, we are safe in using the dull earth-reds—beautiful low-toned, ochrous colours—such as *light red* or *Venetian red.* But, unfortunately, no mineral or earth rose-red is known. The best, and most nearly permanent, are the *madders, rose madder* and *madder carmine* preferably—rich and beautiful colours. The *crimson lakes* of the old paint-boxes are as bad as they are beautiful.

Scarlet is a necessary colour, but even the best, *Chinese vermilion,* is inclined to go black under certain conditions. The red-leads and orange reds are deadly pigments, bad in themselves and destructive to others.

Burnt sienna is a very fine passage from red to brown.

Of the browns, *raw* and *burnt umber* are safe; neither the *Vandyke brown* in oils, nor the *sepia* of water-colours, is wholly safe. But there is a warm brown—the *Caledonian brown*—that has a good reputation. Never, under any consideration, use the beautiful, glowing bitumen, or asphaltum, which spells ruin to a picture.

Of the blacks all are safe, *ivory black* being the usual one.

Colours to be Avoided. Colours to be avoided in oils and in water-colours are the following: the chrome yellows, Naples yellow, orpiment, the yellow pinks, brown pink, alizarine yellow; verdigris green, emerald, sap, Hooker's green; Prussian blue, Antwerp blue, Royal blue, indigo, verditer; the lakes, orange, vermilion, dragon's blood; bitumen, asphaltum, Vandyke brown, sepia, Payne's grey, and the like. It is bitumen, or asphaltum, that causes those great cracks and the utter destruction of so many old masters.

Having settled upon the gamut of his palette, the student has to decide on the vehicle he will use to thin his paint, and to make it flow when so required. Now, in choosing a vehicle, one requires something that will bind the paint so as to save it from contact with air and damp. The best medium is copal and Venetian turpentine. But the drawback to the use of a medium is that it yellows with time. Some artists use none, painting with solid paint. Some, like Whistler, only use turpentine and linseed-oil to thin the colour. Others use a vehicle like the copal medium sold by Newman, of Soho; but there are many upon the market, and in this matter the student must decide for himself. An excellent book, both on medium and colour, is Professor Church's "Chemistry of Paints and Paintings," which no artist should be without.

A word should perhaps be said before proceeding to the painting. To get the colours off the palette and brushes at the end of the day's work, it is best to clean the palette roughly with the palette-knife, and the necessary rag or "waste" dipped in turpentine will do the rest with ease. The brushes should be rough-cleaned on a piece of paper, then dipped in turpentine and dried; or, to get them cleaner still, wash the remaining matter with soap and warm water. Always dry them on a rag.

Continued

Group 1
AGRICULTURE
6
Continued from page 638

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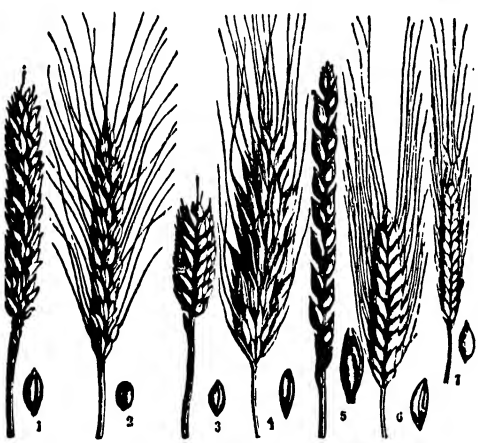

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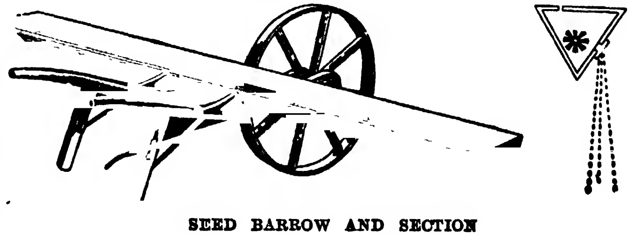

SEED BARROW AND SECTION

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THE COMMON OAT
[Avena sativa]

Scotch, on a much smaller area, 35¾ bushels. The grain weighs about half as much as the total crop, while the straw varies from 12 cwt. to 1 ton per acre. The most suitable temperature for the germination of the grain is that which applies to wheat. The chief barley-growing counties, taking them in order, are Lincoln, Norfolk, Suffolk, the North Riding and the East Riding of Yorks, and Essex.

A fine sample of barley should be plump, covered with a thin, wrinkled skin, the colour of which should be from very pale yellow to light gold colour. It should be dry and sweet, and the ends of the grain finely pointed.

Malt is barley which has been germinated on a malting floor after being soaked in water. A portion of the starch of the grain is converted into sugar in the process. The sprouts—*i.e.*, the *radicle* and the *plumule*, which have developed during germination, are removed as one of the operations of the maltster, and being sweet food, rich in albuminoids, are sold to stockfeeders, to whom they are known as *malt coombs*, or *combs*.

Rye. Rye (*Secale*) is little grown in this country for seed, but 65,000 acres were cropped in the year 1904, the chief object being the production of green fodder for spring use. Rye is largely grown upon the Continent of Europe, especially in the Northern countries, as wheat is grown by us, for the production of bread. Rye resembles wheat more closely than either barley or oats; it is heavier in weight than either of the last-named, while it is better adapted as a food for man. Its chief value to the farm is in the fact that it will grow with success upon poor soils, even those which are extremely sandy in character and at comparatively high altitudes. There is but one species (*S. cereale*), and but few varieties. A crop of rye varies from 3 to 3½ quarters, or 24 to 28 bushels, a bushel weighing about 54 lb. and comprising about a million seeds. The quantity of straw produced, which is about one-third of the total weight of the crop, varies from 1½ to 2 tons per acre.

In sowing rye, from 2 to 4 bushels of seed are used, the quantity depending upon whether the drill is employed or whether the seed is broadcasted by hand. Good seed should be clean, even, bright, and smell sweet; as in other cases it is important to notice whether it is the produce of a crop which has been heated in the stack, or which, having been subjected to frequent rain, has sprouted in the sheaf. Rye is occasionally grown in this country for the sake of the straw, which is the most valuable of any kind for thatching and other purposes where clean, straight, strong, and tough straw is needed. For a green, or catch, crop, rye is sown in the autumn, in September, or October, and may be mown in the early spring, as it is one of the very earliest plants ready for the scythe, in time for turnips, cabbage, rape—maize in the Southern counties—and every other plant which can be sown after the middle of May.

The Pea. The pea (*Pisum*), like the cereals, is an annual, known as a pulse, and belongs to the natural order *Leguminosæ*, the chief feeding constituent of which is legumin, a material resembling the casein of milk. The pod of the pea, as of other plants of this order, is known as a legume. Although there is but one species (*P. sativum*), there are several varieties known to the farmer, these including field peas, which are grey, blue, and maple, or mottled, in colour, and garden peas, which are specially grown for the table. The pea is also grown for cutting green as a forage crop, especially in the United States. The largest crops are grown upon loams which are rich in lime, but the pea thrives on dry clays, sands, and gravels, where lime is present.

On the average of ten years the pea crop of Great Britain has yielded 26¼ bushels per acre, slightly more in England, slightly less in Scotland, and considerably less in Wales, in both of which countries the area sown is small. A bushel of peas weighs from 63 to 65 lb., and contains nearly 100,000 seeds. The yield of straw, which is a valuable food for stock, reaches 1¼ tons to the acre. Peas are now chiefly sown in the months of February and March at the rate of 2 to 5 bushels to the acre, the smaller quantity with the drill, and the larger by hand. Table peas, which are frequently grown in the field, may be sown until the end of April. Good seed may be recognised by its clean, hard, and dry condition, and by its evenness in colour and size.

VETCH
[Vicia sativa]

The Bean. The field bean (*Faba vulgaris arvensis*), also a pulse, is largely grown in this country on the heaviest classes of soil and between two cereal, or white straw crops. It is also a cleaning crop, for, being sown in rows wide apart, the farmer is able to pass the horse hoe between, and thus to cut up the weeds. The average yield of beans covering ten years is 28¼ bushels to the acre, the crop being chiefly grown in England. The bushel weighs from 63 to 65 lb., and contains from 38,000 to 42,000 seeds. The husk of the bean forms about one-seventh of its weight. The straw or haulm, which is useful as a food for stock, reaches from 1¼ to 1½ tons to the acre. The seed is usually drilled at the rate of 2 to 2½ bushels to the acre, but it is sometimes dibbled by hand, when still less is required, and occasionally broadcasted, when as many as 4 bushels are needed. More seed is needed in spring than in autumn. Seed sown in autumn is known as the winter bean, and is specially hardy and vigorous, the plant withstanding severe weather unless the soil is wet.

Good seed is bright and uniformly light brown in colour, well formed, even in size, clean and sweet. Black seeds are objectionable.

THE GRASSES

With the green fields, by which we mean our meadows and pastures, are largely associated buttercups and daisies, that remind us of the misplaced admiration of our youth. Like many other plants, however, these are but indications of poor soils and inferior herbage. The grass field should, as far as man can control it, produce nothing but those among the cultivated grasses and plants of the clover family which are suitable to the soil and the climate. There are cultivated and uncultivated grasses, as there are weeds, which are practically indigenous to particular soils and to the districts in which they grow. The grasses proper belong to the natural order *Gramineæ.* They are grown for the purpose of enabling cattle to feed by grazing, and for mowing for the production of hay.

There is, however, a distinction between the pasture and the meadow. In the former, the plants cultivated should be in such variety, especially as far as their dates of maturity are concerned, that there is a constant succession of young herbage, from the early growing foxtail to the later growing fescues and timothy. Among the cultivated grasses are many which are of quite secondary character, or which are practically worthless, owing, among other reasons, to the small quantity of herbage which they produce, or to the fact that their feeding properties are small. Among these are Yorkshire Fog, darnel, poa annua, quaking grass, tussac grass, barley grass, and the bents. Some grasses, like many weeds which find their way into the meadow and the pasture, are almost as troublesome as couch, or twitch, which, although a grass proper and closely allied to the wheat plant, is one of the greatest opponents of the British farmer, and one which, like weeds and inferior grasses in general, occupies places in which the superior grasses should be growing. The following is a list of the grasses of the first rank, and we supplement them with a few of the best of those of the second rank tabulated below

The chief secondary grasses are fiorin, red fescue, soft brome, Yorkshire Fog, schaders brome, and floating sweet grass.

The ear of a grass plant is known as the *panicle,* while the small ears of each panicle are termed *spikelets,* at the base of which are two small shell-like leaves, which are known as *glumes,* these enclosing the florets. At the base of each floret are two leaf-like structures known as the flowering *glume* and the *palea.* Some of the grasses, like Italian rye grass, are awned, the *awn,* or horn, rising from the back or tip of one of the flowering glumes. The stem of the grass is known as the *culm.* In some instances the stem is prostrate, and know as the *stolon,* travelling underground, and throwing up leaves on its way, as is the case with fiorin.

Perennial Rye Grass. This is usually recognised when flowering by the flatness of the spikelets, which rise alternately on each side of the stem. It is one of the most common as well as the best of all cultivated grasses, growing with great freedom and luxuriance in all rich, deep soils, especially those of the heavier class. It stools freely, throwing up leaves from its roots, and provides abundance of rich, close herbage, for which reason it is an admirable grass, whether for meadows or pastures. Rye grass is sold under various names, but all, Italian excepted, are practically the same. It is useful for leys—*i.e.,* temporary meadows or pastures intended to be left for more than one year. It is hardy, and should form part of all seed mixtures on medium to heavy land.

Italian Rye Grass. This is an early annual and a vigorous grower, responding liberally to liquid manure and irrigation. It is an excellent forage grass for green consumption or hay, and we have known it cut, especially in Scotland, several times in a season after liquid manuring. It makes good silage, produces 30 to 40 cwt. of hay at one cut, or 20 bushels of seed where seed is taken; but, being a coarse feeder, it needs well manuring.

Meadow Foxtail. This is a stoloniferous plant, with a handsome, soft-eared, tail-like head, of a greyish colour. It is one of the earliest grasses to grow, provides plenty of rich herbage, is hardy, and likes deep moist soils not actually wet.

Cocksfoot. This is a big, coarse, bluish grass, sometimes described as orchard grass. It is deep rooted, grows in tufts, provides abundant herbage, and prefers moist soils.

English Name.	Botanical Name.	Percentage of germination.	Weight per bushel.	No. of seeds in lb.	No. of germinating seeds in lb.	Cost of 1,000,000 germinating seeds.
			lb.			s. d.
Perennial rye grass	Lolium perenne	96	28	223,000	214,080	1 2
Italian rye grass	Lolium Italicum	98	23	270,000	264,600	1 1
Meadow foxtail	Alopecurus pratensis	90	14	490,000	441,000	2 10
Cocksfoot	Dactylis glomerata	95	22	426,000	404,700	2 4
Timothy, or catstail	Phleum pratense	98	50	1,320,000	1,293,600	3½
Smooth-stalked meadow grass	Poa pratensis	97	30	1,860,000	1,581,000	7
Rough-stalked meadow grass	Poa trivialis	97	30	2,235,000	2,167,950	9
Wood meadow grass	Poa nemoralis	88	24	2,325,000	2,046,000	10
Sweet vernal grass	Anthroxanthum odoratum	80	16	738,000	590,400	5 11
Golden oat grass	Avena flavescens	80	14	1,400,000	1,120,000	2 6
Tall oat grass	Avena elatior	90	16	138,000	124,200	8 9
Meadow fescue	Festuca pratensis	99	30	236,000	233,640	2 8
Tall fescue	Festuca elatior	96	24	246,000	236,160	6 10
Fine-leaved sheep's fescue	Festuca ovina tenufolia	85	29	1,561,000	1,326,850	1 0
Hard fescue	Festuca duriscula	95	24	578,000	549,100	1 2
Crested dogstail	Cynosurus cristatus	93	40	886,000	823,980	1 10

TALL FESCUE

Timothy, or Catstail Grass. The flower of timothy somewhat resembles that of foxtail, but is much greater in length, and is rougher. Timothy is a late flowering grass, quite hardy, bears greyish leaves, and grows well on clays. The best seed comes from America. When sown alone, although this is seldom advisable in England, 18 to 20 lb. a bushel are required per acre.

Smooth-stalked Meadow Grass. This is somewhat shallow rooted, an early grower, and a good pasture grass, which thrives on dry soils.

Rough-stalked Meadow Grass. This is also a good pasture grass, thriving best on rich, heavy soils.

Wood Meadow Grass. This closely resembles the two last named, and, although useful, is but little employed in grass mixtures.

Sweet Vernal Grass. Although early, and, therefore, useful in a pasture, this is of quite second-rate value, owing to the small quantity of the herbage it produces. It has, however, one important virtue—it imparts a sweet odour to the hay in which it is conspicuous.

Golden Oat Grass. This handsome plant, with its bright yellow panicle, is well adapted to soils of medium character; it grows with freedom, and provides abundance of excellent herbage, whether for pasture or for hay.

Tall Oat Grass. This somewhat large plant we have often regarded as a weed when prevalent in hedgerows, and such it then is; but when forming a part of a meadow it is of considerable value, owing to its vigour, its size, and its usefulness as a food. It prefers the medium clays and loams, and is occasionally found in land under the plough with a bulb above its root.

Meadow Fescue. One of the most useful of cultivated grasses for meadows and pastures is meadow fescue. It does not thrive so well in a dry climate, preferring clays and moist soils in general.

Tall Fescue. This is a robust plant of large size, but somewhat closely resembles meadow fescue in its general character.

Sheep's Fescue. Better adapted for downs and other sheep pastures is sheep's fescue. Its herbage is fine and rich, though not abundant in quantity.

Hard Fescue. This somewhat resembles sheep's fescue, is useful in a mixture, and valuable for sowing in the drier soils.

Red Fescue. This is a vigorous grower, resembling the two last-named grasses; it is useful for pastoral purposes, but of little value for hay. It grows well in second-class soils.

Fine and various Leaved Fescues. These may be classed with the other varieties, assisting to form useful herbage.

Crested Dogstail. This is a wiry, deep-rooted grass, not one of the best, but useful on a sheep pasture, and especially on dry and chalky soils. It is common, however, to find the ear untouched by stock when autumn arrives.

Fiorin, or Creeping Bent. Owing to its prostrate stem and underground growth, this grass soon covers a large space of ground, where the soil suits its habit. It prefers damp

COCKSFOOT

Dr. Stebler's Calculation of Seed Mixtures.	To consist of	Addition to pure sowing.	Weight of each kind of seed in the mixture per acre. Pure and germinating seed.	Weight of each kind of seed in the mixture per acre. Commercial seed.
	Per cent.	Per cent.	lb.	Per cent.
Red clover	40	15	7	8 lb. containing 88
Alsike	30	10	3	4 ,, ,, 73
Italian rye	10	10	3½	5 ,, ,, 67
False oat grass	10	10	3½	7 ,, ,, 49
Timothy	10	10	2½	3 ,, ,, 87
			19½	

SEEDS FOR PERMANENT PASTURE.

Medium Soils (lb. per acre).

Grasses.	Stephens.	Laune.	Sutton.	Mc Connell
Timothy	2½	3		
Meadow fescue	3½	6	5½	
Tall fescue		3	—	
Cocksfoot	4	7	4	
Dogstail ..		2	½	
Sweet vernal		—		
Foxtail ..		10		1
Perennial rye grass		—		10
White clover		1		3
Cowgrass..		1		2
Alsike clover ..	1½	1		3
Perennial red clover		1		2
Trefoil				3
Italian rye grass				5
Rough-stalked meadow grass				
Yellow oat grass				
Various leaved fescue	1			
Sheep's fescue	1½			
Hard fescue ..	3			
Red fescue ..	2			
Smooth-stalked meadow grass	½			
Wood meadow grass	½		½	
Lucerne	1		1	
Fiorin		1½		
Yarrow				
		40	40	

situations, and is useful for providing food in late pastures.

As with oats and barley, members of the same order, the seed of most of the best grasses consists of the entire dried flower, or floret, including the glume and the palea. This, however, is not the true seed, which may be regarded as a ripe ovule within the floret.

If grass seed guaranteed 95 per cent. pure has only a germinating power of 80 per cent., we have only 76 per cent. of pure germinating seed, thus $\frac{95 \times 80}{100} = 76$.

The quantity of pure germinating perennial rye grass seed necessary to sow an acre is 38½ lb. = 54 lb. of commercial seed, whose purity is 95 per cent. and germinating power 75 per cent.

Upon this basis mixtures are made as in Dr. Stebler's table, which appears on this page.

Assuming that 40 lb. of seed are used per acre, the variations in the quantity of each leading variety in accordance with different soils are somewhat as follows: less timothy is employed on sand soils, limestones and chalk, and more dogstail, sheep's fescue, and smooth-stalked meadow grass. On the limestones and chalks sainfoin may be added, while red clover and alsike are omitted on sandy soils. Before preparing seed mixtures the wisest course is to inspect good neighbouring pastures or meadows, and to ascertain what course was followed and what grasses thrive the best. It is also well to study the habits of each variety and what soils they prefer [see table below].

Lucerne at the rate of 5 or 6 lb. to the acre may be employed on the heavy and medium soils, which are deep and contain lime, where the grass is to remain three or four years or more.

MIXTURES FOR LEYS, OR ROTATION GRASSES.

Grasses.	One year. Heavy soils. lb.	One year. Light soils. lb.	Two years. Heavy soils. lb.	Two years. Light soils. lb.	Three or four years. Heavy soils. lb.	Three or four years. Medium soils. lb.	Three or four years. Light soils. lb.
Italian rye grass	11	16	8	12	3	4	6
Cocksfoot	3	2	5	2	5	5	5
Timothy	2	2	2	2	3	3	3
Broad red clover	6	5	5	3	2	1	—
Alsike	3	2	2	2	2	2	2
Trefoil..	3	2	2	2	2	2	2
Perennial rye grass..	—	—	5	5	8	10	13
Meadow fescue	—	—	2	2	3	3	2
Perennial red clover	—	—	2	2	2	2	2
White clover	—	—	—	—	2	2	2
Meadow foxtail	—	—	—	—	2	2	2
Hard fescue	—	—	—	—	2	1	1
Lucerne	—	—	—	—	4	4	—
Total lb. per acre	28	29	33	32	40	41	40

Continued

ROUGH-STALKED MEADOW GRASS

VARIOUS-LEAVED FESCUE

YELLOW OAT GRASS

MEADOW FESCUE

FINE-LEAVED SHEEP'S FESCUE

CRESTED DOGSTAIL

BRITISH GRASSES. 1

SUTTON'S PERENNIAL RYE GRASS

SUTTON'S ITALIAN RYE GRASS

SMOOTH-STALKED MEADOW GRASS

SWEET-SCENTED VERNAL

TIMOTHY GRASS, OR MEADOW CATSTAIL

FIORIN, OR CREEPING BENT GRASS

BRITISH GRASSES. 2

CLIMBING BUCKWHEAT; BLACK

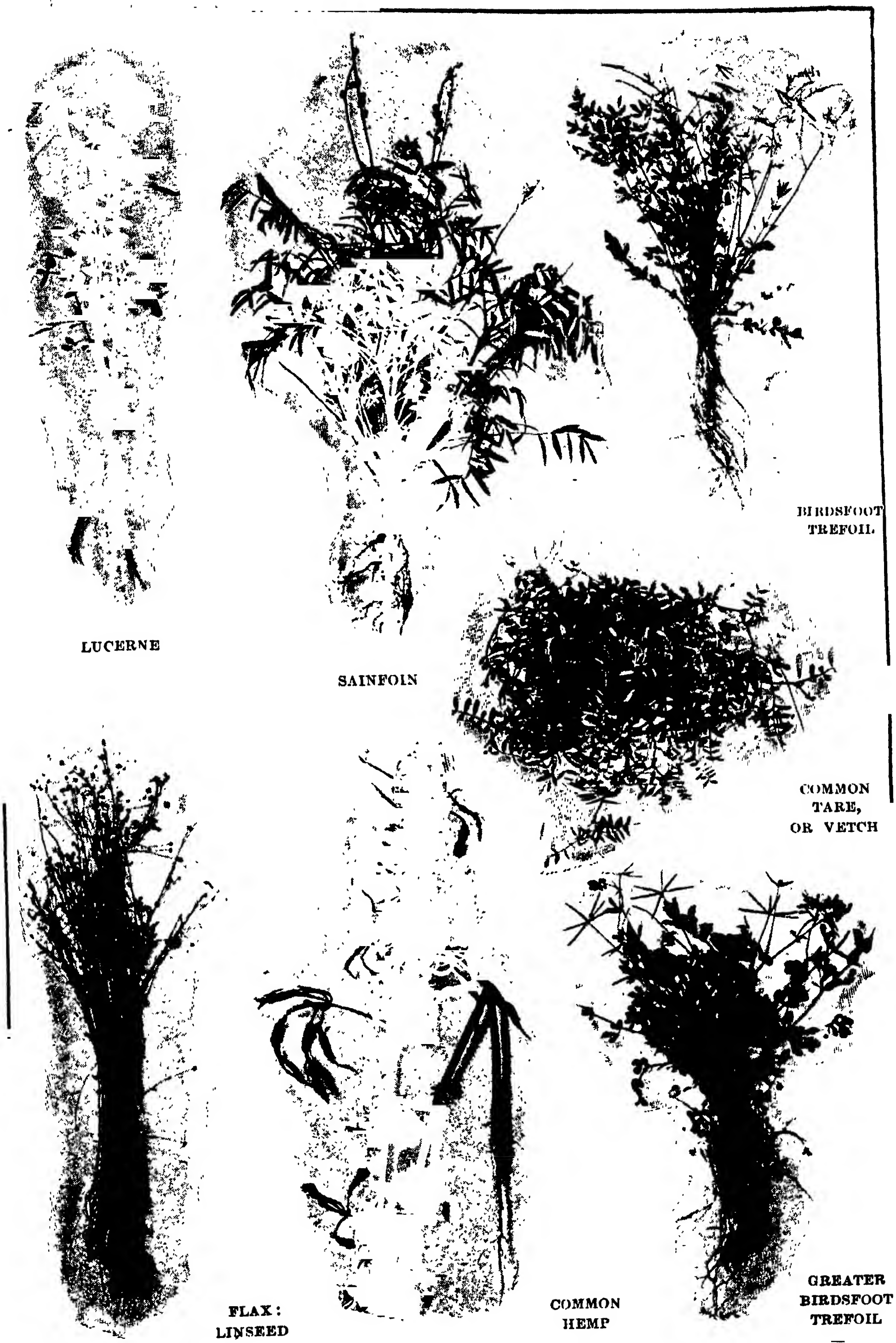
WILLOW HERB, ROSEBAY

SHEPHERD'S PURSE

KNOTGRASS

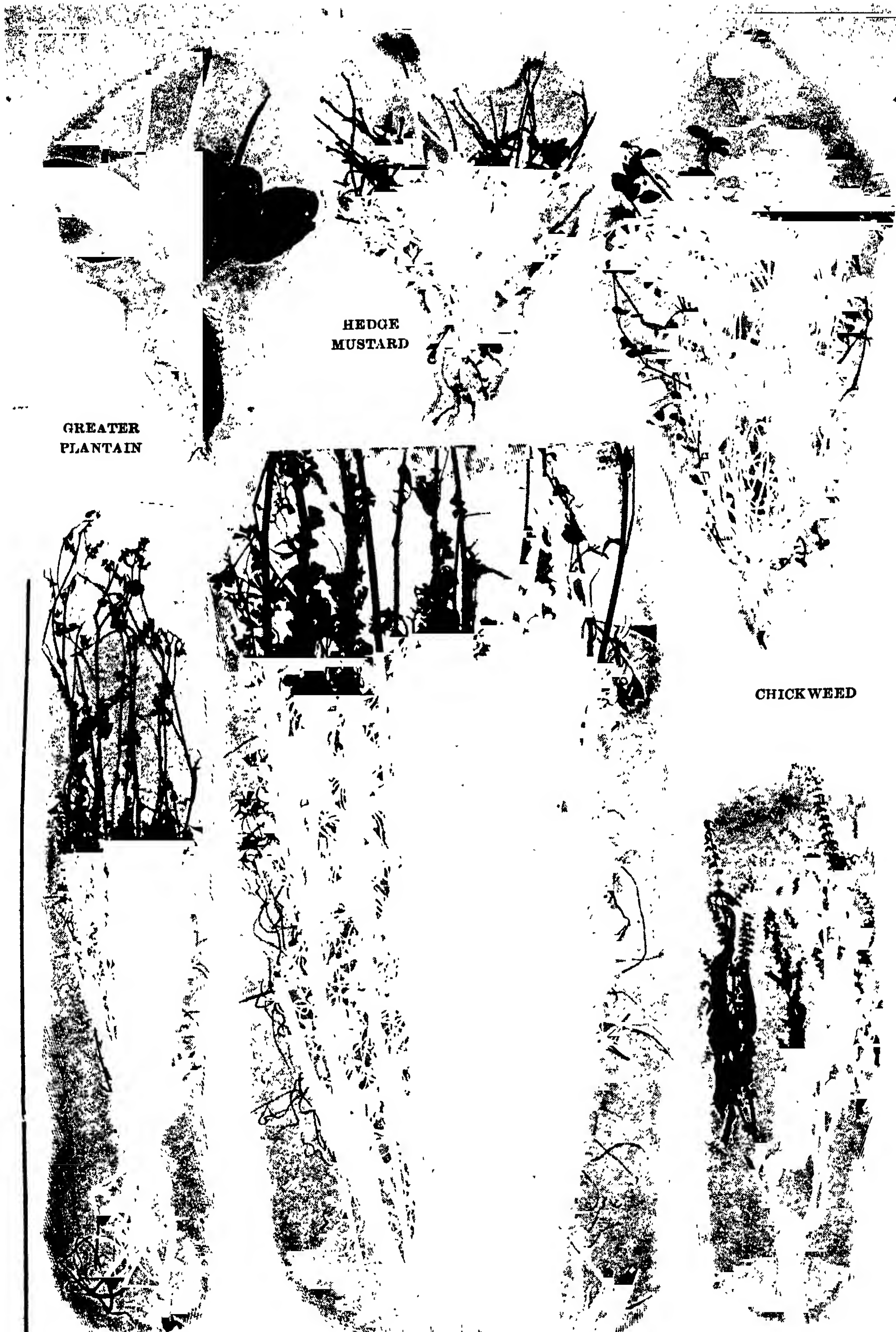
COUCHGRASS

GOOSEFOOT FAT-HEN ETC.



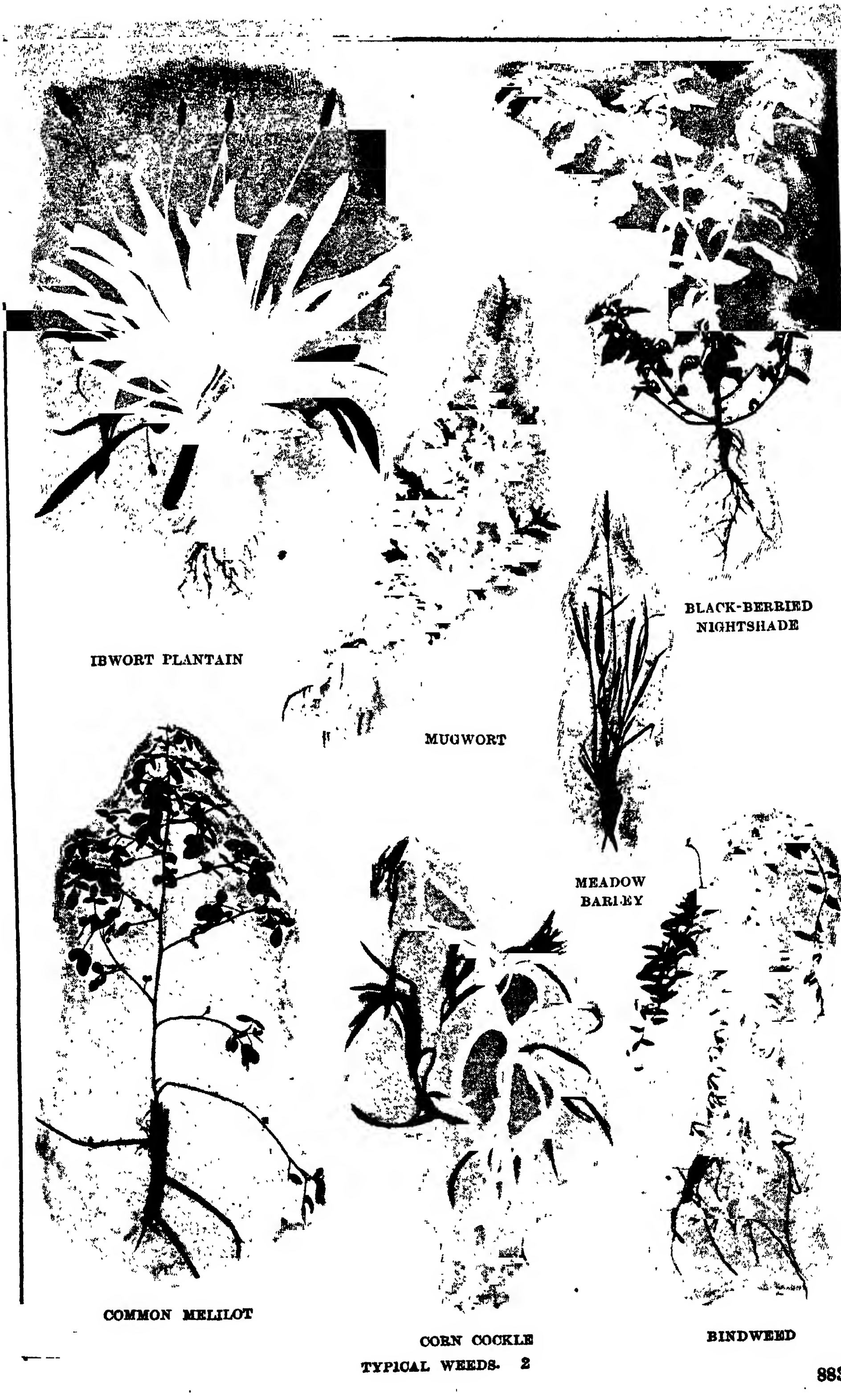
FIVE SPECIMEN LEGUMES, WITH FLAX AND HEMP

For other examples of leguminous herbage see CLOVERS



DODDER ON LUCERNE   DODDER ON LUCERNE [Dodder is a parasitic weed]   BROAD-LEAVED DOCK

TYPICAL WEEDS. 1



IBWORT PLANTAIN

MUGWORT

BLACK-BERRIED NIGHTSHADE

MEADOW BARLEY

COMMON MELILOT

CORN COCKLE

BINDWEED

TYPICAL WEEDS. 2

RECURRING DECIMALS AND PRACTICE

Addition, Subtraction, Multiplication and Division. Examples. Simple and Compound Practice. Key to Examples

By HERBERT J ALLPORT, M.A.

RECURRING DECIMALS

94. In some cases of division, when the quotient is expressed as a decimal, we have found that the quotient does not terminate—for example, Art. 83, Ex. 2.

In such cases, a digit, or set of digits, is repeated continually. The decimal fraction is then called a *recurring*, a *repeating*, or a *circulating* decimal.

The digits which recur are called the *period.*

A *pure* recurring decimal is one in which the period begins immediately after the decimal point. Thus ·3636... and ·7777... are pure recurring decimals.

A *mixed* recurring decimal is one in which the period does not begin immediately after the decimal point. Thus ·23548548..., in which the digits 548 recur but 23 does not recur, is a mixed recurring decimal.

The period is usually indicated by placing a dot over its first and last digits, so that ·363636... is represented by $\cdot\dot{3}\dot{6}$, ·777... by $\cdot\dot{7}$, and ·23548548... by $\cdot 23\dot{5}4\dot{8}$.

95. We can easily tell, without performing the division, whether a vulgar fraction *in its lowest terms* will give a terminating or a repeating decimal; for a terminating decimal is equivalent to a vulgar fraction with 10 or some power of 10, as its denominator. Hence, if we can multiply both numerator and denominator of our vulgar fraction by such a number that the denominator becomes 10, or some power of 10, then the fraction will give a terminating decimal. Now 2 and 5 are the only numbers which can be multiplied so as to become powers of 10. Therefore, if the denominator of the given fraction contains any prime factors which are not either 2's or 5's, the fraction will not form a terminating decimal.

96. Further, we can tell the greatest possible number of digits in the recurring period. Consider the fraction $\frac{2}{7}$. When dividing by 7 the remainder must always be less than 7, so that the only possible remainders are 1, 2, 3, 4, 5, 6. Hence, the next remainder *must* be one which we have already had, and the figures in the quotient will recur, even if they have not done so sooner.

Although the following statements cannot be proved here, a knowledge of them may save much labour.

(1) When the denominator is a prime number, the number of digits in the period is a factor of the denominator-diminished-by-one.

Thus $\frac{1}{13}$ must recur after 1, 2, 3, 4, 6, or 12 digits, since these are the only numbers which are factors of 13 − 1, *i.e.*, of 12.

(2) By division we find $\frac{1}{7} = \cdot\dot{1}4285\dot{7}$. In any multiple of $\frac{1}{7}$, such as $\frac{5}{7}$, these same digits will form the period, and they will follow one another in the same order. By dividing 7 into 50 we see the first digit is 7; hence, we at once know that $\frac{5}{7} = \cdot\dot{7}1428\dot{5}$. This statement is true for any fraction whose denominator is prime, and *the number of digits in whose period is one less than this denominator.*

(3) In $\cdot\dot{1}4285\dot{7}$ we see that, when we have found the first half of the period by division, we can obtain the second half by subtracting the digits already found, in order, from 9. Thus, 8 = 9 − 1, 5 = 9 − 4, 7 = 9 − 2. This fact is of great use in cases such as $\frac{1}{17}$, $\frac{2}{19}$, etc.

For example, we find by division that $\frac{1}{17}$ = ·05882352... and that the quotient does not yet recur. But, by (1) of the present article, since it does not recur after *eight* figures, we know that it *must* recur after 16. Consequently, we can obtain the remaining 8 figures by subtracting the first 8, in order, from 9. Hence, $\frac{1}{17} = \cdot\dot{0}58823529411764\dot{7}$.

97. A pure circulating decimal is converted into a vulgar fraction as follows:

Example 1. Reduce $\cdot\dot{2}$ to a vulgar fraction.

We have $\cdot\dot{2}$ = ·2222 . . . . (1)

There is *one* digit in the period, so we multiply by the *first* power of 10.

Thus $10 \times \cdot\dot{2} = 2\cdot 2222$ . . . . (2)

Subtract (1) from (2), and we get

$$9 \times \cdot\dot{2} = 2$$

Therefore $\cdot\dot{2} = \frac{2}{9}$ *Ans.*

Example 2. Reduce $\cdot\dot{7}1428\dot{5}$ to a vulgar fraction.

$$\cdot\dot{7}1428\dot{5} = \cdot 714285714285\ .\ .\ \ (1)$$

There are *six* digits in the period, so we multiply by the *sixth* power of 10.

Then

$$1000000 \times \cdot\dot{7}1428\dot{5} = 714285\cdot 714285\ .\ .\ \ (2)$$

Subtract (1) from (2) and we get

$$999999 \times \cdot\dot{7}1428\dot{5} = 714285.$$

Therefore,

$$\cdot\dot{7}1428\dot{5} = \frac{714285}{999999} = \frac{5 \times 142857}{7 \times 142857} = \frac{5}{7}\ Ans.$$

Hence we have the rule: *For the numerator, write down the digits which form the period; for the denominator, put down as many nines as there are digits in the period.*

98. Mixed recurring decimals are converted in a similar way.

Example. Reduce $\cdot 3\dot{5}\dot{7}$ to a vulgar fraction

$$\cdot 3\dot{5}\dot{7} = \cdot 3575757\ .\ .\ .\ .$$

There is *one* digit in the non-recurring part, so we multiply by 10, and obtain

$10 \times {\cdot}3\dot{5}\dot{7} = 3{\cdot}575757 \ldots \qquad (1)$

There are *three* digits in the non-recurring part and the period together. Multiply, therefore, by the *third* power of 10.

$1000 \times {\cdot}3\dot{5}\dot{7} = 357{\cdot}5757 \ldots \qquad (2)$

Subtract (1) from (2):

$990 \times {\cdot}3\dot{5}\dot{7} = 357 - 3.$

Hence $\quad {\cdot}3\dot{5}\dot{7} = \frac{357-3}{990} = \frac{354}{990} = \frac{59}{165}$ *Ans.*

We have, therefore, the rule: *For the numerator, write down the number consisting of the digits as far as the end of the first period, and subtract the number consisting of the digits which do not recur; for the denominator, write as many nines as there are recurring digits, followed by as many noughts as there are non-recurring digits.*

99. A decimal whose period is 9 is equivalent to a terminating decimal.

Example. By the above rule

$${\cdot}12\dot{9} = \frac{129-12}{900} = \frac{117}{900} = \frac{13}{100} = {\cdot}13.$$

Or, the same thing may be shown by subtracting ${\cdot}12\dot{9}$ from ${\cdot}13$, the result being zero.

NOTE. From this it appears that ${\cdot}\dot{9} = 1$. This is only true in the sense that the difference between 1 and ·999... becomes less and less as we take more figures of the decimal, until the difference between them is smaller than any assignable quantity. It is, in fact, in this sense that any vulgar fraction is said to be *equal* to a recurring decimal.

100. Addition and Subtraction of Recurring Decimals.

In adding or subtracting recurring decimals, it should be noticed that we can always write the decimals so that their *periods begin at the same decimal place.* For, it is evident that ${\cdot}12\dot{9}3\dot{4}$ may be written ${\cdot}1293\dot{4}9\dot{3}$, since each is equivalent to ·12934934934... We have thus shifted the beginning of the period from the third place to the fifth.

Next, a decimal which has a period of, say, 4 digits, may be considered as having a period of 8, 12, or any other multiple of 4 digits. So that, if we have three decimals, whose periods consist of, say, 2, 3, and 4 digits, we may take the L.C.M. of 2, 3, 4, *i.e.*, 12, and consider that each decimal has a period of 12 digits.

We will now consider examples in addition and subtraction.

Example 1. Add together ${\cdot}25\dot{7}9\dot{3} + {\cdot}124\dot{6}\dot{1} + {\cdot}\dot{3}2\dot{5} + {\cdot}1\dot{2}\dot{4}$.

·257	937937	93
·124	616161	61
·325	325325	32
·124	242424	24
·832	121849	*Ans.*

EXPLANATION. The latest place at which a period begins is the *fourth* (in the second decimal). We therefore, after writing the decimals under one another as in ordinary addition, draw a line in front of the *fourth* place. Next we see that the numbers of digits in the periods are 3, 2, 3, 2 respectively. The L.C.M. of these numbers is 6. Write, then, in each decimal, *six* figures to the right of the line we have drawn, and draw another line after them. Evidently the figures enclosed between the two vertical lines will continually repeat, so that we only need write down two more places of each decimal, in order to find what figure we must "carry," and add the decimals together. The answer will be a decimal of which the part between the vertical lines recurs.

Example 2. Subtract ${\cdot}63\dot{5}6\dot{4}$ from $1{\cdot}\dot{8}7796\dot{8}$.

1·87	796887	79
·63	564564	56
1·24	232323	

Reqd. difference $= 1{\cdot}24\dot{2}\dot{3}$ *Ans.*

EXPLANATION. Make both decimals begin to recur at *third* place. Draw a line in front of the third place. The periods consist of 6 and 3 digits respectively. The L.C.M. of 6 and 3 is 6. Hence, write six figures to the right of the line, draw another line, and continue two places beyond. In this case there is nothing to "carry" from these extra places, and we get for our answer 1·24|232323|, where the figures between the lines form the period. We notice that this period of *six* figures consists of three sets of *two* figures, so that the answer is written $1{\cdot}24\dot{2}\dot{3}$.

101. Multiplication and Division of Recurring Decimals.

Division by a whole number or by a terminating decimal presents no more difficulty than the division explained in Art. 33. We have, of course, to "bring down" the digits which form the period, instead of bringing down 0's.

Example 1. Divide $12{\cdot}\dot{0}\dot{6}$ by 3·7.

```
37 ) 120·606060... ( 3·259623 Ans.
     96
     220
      356
       230
        86
        120
          9
```

EXPLANATION. We have to divide 12·0606... by 3·7, *i.e.*, 120·606... by 37. Proceeding as in ordinary division, we find, after getting six figures of the quotient, that we obtain a remainder 12. This, with the 0 brought down from the dividend, gives 120, and we have already divided 37 into 120, at the beginning of the work. In the first case, however, the division did not give a digit in the *decimal* part of the quotient, so we have to proceed one step further, obtaining 3 in the quotient and 9 remainder. It is clear that all the digits in the decimal part of the quotient will now recur. Hence the answer is $3{\cdot}\dot{2}5962\dot{3}$.

Example 2. Multiply $4{\cdot}\dot{2}1\dot{3}$ by 3·25.

In multiplication by a whole number or by a terminating decimal, we write down the multiplicand as far as the end of two periods, and then two places more, so as to "carry" the correct figure. Write the multiplier with its unit's digit under the last digit of the second period, and proceed as in ordinary multiplication.

Thus:

```
4·|213|213|21
         3·25
 12|639|639|6
   |842|642|6
   |210|660|6*
13·692|942|
```

Or, $13{\cdot}69\dot{2}9\dot{4}$ *Ans.*

N.B. It must be remembered that the last two places of the multiplicand are only used to enable us to carry the correct figure. Thus, in multiplying by 5, we say, five 1's, 5; but *we put nothing down.* Then

five 2's, 10, and again put nothing down; but we now know we must add-in the 1 carried, when we begin the multiplication of the period —*i.e.*, five 3's, 15, and 1, 16. This 6, according to the ordinary rule, would come *under the multiplier* 5, and is not needed in the above example. We proceed, five 1's, 5, and 1, 6; which is the 6 marked * in the working. Again, if there are many digits in the multiplier, it *may* be necessary to fill in one or two more periods of each separate product before adding them together. Thus, in the above example, had there been many more lines of multiplication, we might have had to continue the 639 of the first line, the 642 of the second, the 660 of the third, and so on, in order to find the period of the sum of all the lines.

102. If the multiplier is a recurring decimal, we *must* express it as a vulgar fraction. In some examples the work is simpler if we also express the multiplicand as a vulgar fraction, in which case we proceed as in multiplication of fractions and then convert the result into a decimal. The student must use his judgment as to which method is best suited to any particular example.

The same remarks apply to division by a recurring decimal.

Example 1. Multiply $3{\cdot}\dot{1}4285\dot{7}$ by $\cdot\dot{6}\dot{3}$.

Here it is simpler to reduce both to vulgar fractions.

For $\qquad 3{\cdot}\dot{1}4285\dot{7} = 3\frac{1}{7}$

and $\qquad \cdot\dot{6}\dot{3} = \frac{63}{99}$

Their product $\qquad = \frac{\overset{2}{\cancel{22}}}{\cancel{7}} \times \frac{\overset{\cancel{7}}{\cancel{63}}}{\underset{\cancel{9}}{\cancel{99}}} = \underline{2\ \textit{Ans.}}$

Example 2. Divide $3{\cdot}\dot{1}2\dot{8}$ by $1{\cdot}\dot{3}$.

The divisor $= 1\frac{3}{9} = 1\frac{1}{3} = \frac{4}{3}$. To divide by $\frac{4}{3}$ we multiply by $\frac{3}{4}$.

Thus:

$$\begin{array}{r} 3{\cdot}12812\ldots \\ 3 \\ \hline 4)\overline{9{\cdot}\dot{3}8\dot{4}} \\ \underline{2{\cdot}346\dot{0}9\dot{6}\ \textit{Ans.}} \end{array}$$

EXAMPLES 12

1. Add together $3{\cdot}12\dot{6}\dot{4} + {\cdot}008\dot{3} + 10{\cdot}9\dot{6}1\dot{4}$.

2. Find the value of $7{\cdot}1\dot{2}3\dot{4} - {\cdot}\dot{0}25\dot{7} + 3{\cdot}54\dot{3}2\dot{1} + 11{\cdot}257 - 9{\cdot}\dot{3}\dot{6}$.

3. Express $2{\cdot}25\dot{2}8571\dot{4}$ as a vulgar fraction in its lowest terms.

4. Express £15 13s. 7½d. as the decimal of £99 6s. 3½d.

5. Find the value of ${\cdot}1\dot{3}\dot{6}$ of £7 14s. 11d. $-$ ${\cdot}0\dot{2}5\dot{4}$ of £6 0s. 3¾d.

6. Simplify, giving the answer as a decimal, ${\cdot}7\dot{3}$ of $1{\cdot}23\dot{4}$ of 12.

7. Show that the decimals equivalent to $\frac{1}{7}, \frac{2}{7}, \frac{3}{7}, \frac{4}{7}, \frac{5}{7}, \frac{6}{7}$, can be arranged in a square so that the sum of each row, of each column, and each diagonal, is the same.

8. Find the greatest decimal fraction which, when divided into ${\cdot}13\dot{6}$ and into ${\cdot}\dot{8}\dot{2}$, gives a whole number for quotient in each case.

9. A warehouse consists of three floors; the rent of each floor is ${\cdot}\dot{8}\dot{1}$ of the rent of the floor below; that of the top-floor is £51 6s. What is the rent of the ground floor?

10. A train puts down ${\cdot}\dot{3}8461\dot{5}$ of its passengers at its first stop, and 57 people at its second stop. It now has ½ of the original number left. How many passengers were there when the train started?

PRACTICE

103. Practice is a convenient method by which we find the value of any quantity when we know the value of one of the units in terms of which the quantity is expressed.

In *simple* practice we have to find the value of a *simple* quantity; in *compound* practice, the value of a *compound* quantity.

The method is as follows:

In simple practice we break up the value of a single unit into component parts, each of which *measures* [see Art. 57] one of the preceding component parts. It is then easy to obtain the value of the given quantity when the value of a unit is each of these component parts, in turn; after which, we add the several results.

In compound practice we break up the given compound quantity into components in the same way, and, after finding the value of each component, we add the results.

Such components are called *aliquot parts.* Thus, an aliquot part of a quantity is a part which measures that quantity, and therefore it is a fraction of the quantity whose numerator is 1.

Examples.

3s. 4d. is an aliquot part of £1, since 3s. 4d. $= \frac{1}{6}$ of £1.

14 lb. is an aliquot part of 1 cwt., since 14 lb. $= \frac{1}{8}$ of 1 cwt.

104. A few examples will make the method clear.

Example 1. Find the value of 3128 tons at £1 8s. 6d. per ton.

Here we have a simple quantity, *viz.*, 3128 tons, and we are given the value of a unit.

The work is arranged thus:

	£	s.	d.	
	3128	0	0	= cost at £1 per ton
5s. = ¼ of £1	782	0	0	= ,, 5s. ,,
3s. 4d. = $\frac{1}{6}$ of £1	521	6	8	= ,, 3s. 4d. ,,
2d. = $\frac{1}{20}$ of 3s. 4d.	26	1	4	= ,, 2d. ,,
	£4457	8	0	*Ans.*

Explanation. The cost of 3128 tons at £1 per ton is evidently £3128. Next, 5s. = ¼ of £1, and therefore the cost at 5s. a ton will be one quarter of the cost at £1, so that we obtain the cost at 5s. by dividing £3128 by 4. Again, 3s. 4d. = $\frac{1}{6}$ of £1, therefore, divide the cost at £1 by 6 to obtain the cost at 3s. 4d. Similarly, since 2d. = $\frac{1}{20}$ of 3s. 4d., we divide the cost at 3s. 4d. by 20 to obtain the cost at 2d. Finally, we add the several costs, *viz.*, at £1, at 5s., at 3s. 4d., and at 2d. to obtain the cost at £1 8s. 6d.

Example 2. Find the cost of 7692¼ articles at £3 16s. 4½d. each.

	£	s.	d.	
10s. = $\frac{1}{2}$ of £1	7692	5	0	= cost at £1 each
			3	
	23076	15	0	= „ £3 „
5s. = $\frac{1}{2}$ of 10s.	3846	2	6	= „ 10s. „
1s. 3d. = $\frac{1}{4}$ of 5s.	1923	1	3	= „ 5s. „
$1\frac{1}{2}$d. = $\frac{1}{10}$ of 1s. 3d.	480	15	$3\frac{3}{4}$	= „ 1s. 3d. „
	48	1	$6\frac{3}{8}$*	= „ $1\frac{1}{2}$d „
£	29374	15	$7\frac{1}{8}$	*Ans.*

* In dividing the previous line by 10, we obtain 3d. remainder from the pence. This, with the $\frac{3}{4}$d. makes $\frac{15}{4}$d., and $\frac{15}{4} \div 10 = \frac{15}{40} = \frac{3}{8}$d.

Sometimes the work is considerably shortened if we *subtract* one or more aliquot parts, as in the next example.

Example 3. Find the cost of 107 things at £17 17s. $10\frac{1}{2}$d. each.

Here, the value of each article is 2s. $1\frac{1}{2}$d. short of £18. We find the cost at £18, and subtract the cost at 2s. $1\frac{1}{2}$d.

	£	s.	d.	
2s. = $\frac{1}{10}$ of £1	107	0	0	= cost at £1 each
			3	
	321	0	0	
			6	
	1926	0	0	= „ £18 „
$1\frac{1}{2}$d. = $\frac{1}{16}$ of 2s.	10	14	0	= „ 2s. „
		13	$4\frac{1}{2}$	= „ $1\frac{1}{2}$d. „
£	1914	12	$7\frac{1}{2}$	*Ans.**

* Subtract the two lines from £1926 by the method of Art. 43.

Example 4. Find the cost of 4 tons 12 cwt. 80 lb. at £3 15s. per ton.

	£	s.	d.	
10 cwt. = $\frac{1}{2}$ of 1 ton	3	15	0	= cost of 1 ton
			4	
	15	0	0	= „ 4 tons
2 cwt. = $\frac{1}{5}$ of 10 cwt.	1	17	6	= „ 10 cwt.
70lb. = $\frac{1}{16}$ of 10 cwt.		7	6	= „ 2 cwt.
10 lb. = $\frac{1}{7}$ of 70 lb.		2	$4\frac{1}{8}$	= „ 70 lb.
			$4\frac{1}{56}$	= „ 10 lb.
£	17	7	$8\frac{1}{7}$	*Ans.*

Example 5. Find the cost of 15 miles 6 fur. 200 yd. at £31 6s. 8d. per mile.

Here 240 yd. more would make 16 miles. Therefore, we have:

	£	s.	d.	
160 yd. = $\frac{1}{11}$ of 1 mile	31	6	8	= cost of 1 mile
			4	
	125	6	8	
			4	
	501	6	8	= „ 16 miles
80 yd. = $\frac{1}{2}$ of 160 yd.	2	16	$11\frac{7}{11}$	= „ 160 yd.
	1	8	$5\frac{9}{11}$	= „ 80 yd.
By subtraction £	497	1	$2\frac{6}{11}$	*Ans.*

EXAMPLES 13

1. Find the cost of 3256 head of cattle at £14 17s. 10d. per head.

2. Find the value of $729\frac{1}{2}$ dozen walking-sticks at £3 4s. $7\frac{1}{2}$d. per dozen.

3. What will it cost to fence 6 fur. 72 yd. at £3 15s. a furlong?

4. A bankrupt pays 14s. $5\frac{1}{4}$d. in the £. How much will a creditor receive to whom the bankrupt owed £743 10s.?

5. Find the value of 743·875 oz. of silver at 2s. 8d. per oz.

6. Find in £ s. d. the value of 32·8625 of £3 11s. 4d.

7. What will be the rent of 5 a. 2 r. 16 p. at £4 2s. 6d. per acre?

8. Find the cost of 33 miles 5 fur. 180 yd. of telegraph wire, at £12 13s. 6d. per mile.

9. What is the value of 1 ton 15 cwt. 91 lb. at £1·4625 per cwt.?

10. Find the cost of 1 a. 3215 sq. yd. at 2s. $2\frac{1}{2}$d. per sq. ft.

Answers to Arithmetic

Examples 4

1. £52 14s. $8\frac{3}{4}$d. 2. £164 18s. $6\frac{1}{2}$d. 3. £381 17s. 3d. 4. £175 12s. 9d. 5. £52 1s. 8d. 6. £2083 6s. 8d. 7. £130 8s. 6d. 8. £3766 2s. 6d. 9. 9 wk. 1 dy. 2 hr. 37 min. 10. 1 wk. 2 dy. 18 hr. 3 min. 18 sec. 11. 3 wk. 2 dy. 3 hr. 33 min. 20 sec. 12. 13 tons 16 cwt. 1 qr. 14 lb. 8 oz. 5 dr. 13. 12 tons 3 cwt. 24 lb. 14. 16 tons 10 cwt. 3 qr. 20 lb. 15. 1 ton. 16. 4 lb. 2 oz. 4 dwt. 6 gr. 17. 10 lb. 6 oz. 9 dwt. 13 gr. 18. 175 lb. 5 oz. 3 dwt. 19. 4 miles 4 fur. 32 po. 5 yd. 6 in. 20. 27 miles 99 yd. 21. 43 miles 1 fur. 9 ch. 24 lks. 22. 48 lea. 7 fur. 25 po. 2 ft. 9 in. 23. 2 a. 1 r. 27 p. 29 yd. 16 in. 24. 46 a. 1918 yd. 8 ft. 143 in. 25. 9 a. 3 r. 14 p. $5\frac{1}{2}$ yd. 26. 6 sq. miles 115 a. 4228 yd. 27. 169 cu. yd. 6 cu. ft. 200 cu. in. 28. 16 cu. yd. 17 cu. ft. 42 cu. in. 29. 30011 bush. 2 pk. 3 qt. 1 pt. 30. 13153 qr. 1 gall.

Examples 5

1. 952 gs. + 8s. 2. 222 fourpences + 3d. 3. 29988 half-crowns. 4. 112 half-guineas + 3 florins 5. 1 cwt. 93 lb. 5000 gr. 6. 5840 poles. 7. 30408 crowns. 8. 2994 lb. 5 oz. 6 dwt. 16 gr.

Examples 6

1. £212 6s. $10\frac{1}{4}$d. 2. £21 12s. 10d. 3. 5 cwt. 15 lb. 15 oz. 4. £17 18s. $11\frac{1}{2}$d. 5. 4 a. 4195 sq. yd. 8 sq. ft. 6. 60 a. 16 p. $29\frac{3}{4}$ yd. 7. 2 bush. 1 pk. 3 qt. 1 pt. 8. £94 13s. 11d.

Examples 7

1. 277 miles 3 fur. 172 yd. 2. 4 tons 19 cwt. 3 qr. 12 lb. 9 oz. 3. £164084 4s. 3d. 4. £16 1s. 9d. + 104 far. rem. 5. 304. 6. 5 half-crowns. 7. Giving 3 men 10s. each first, leaves £53 15s. 10d. − £1 10s. = £52 5s. 10d. to be divided equally amongst the 10 men; which gives £5 4s. 7d. for each. Hence, 7 men have £5 4s. 7d. each and the other 3 have £5 14s. 7d. 8. Giving 2 men out of 7 twice as much as the others makes the share of the others the same as if there were 9 men. ∴ 5 of the men get £11 9s. 6d. ÷ 9 = £1 5s. 6d. each. The other 2 men get 2 × £1 5s. 6d. = £2 11s. each. 9. A bat costs as much as 5 balls. ∴ 1 guinea will buy 6 balls. Hence, the ball costs 21s. ÷ 6 = 3s. 6d. The bat costs 21s. − 3s. 6d. = 17s. 6d. 10. At the lower price she saves 3d. on each dozen. ∴ On 12 dozen she saves 3d. × 12 = 3s. Hence, at the lower rate, she

could have bought 2 dozen eggs for this 3s., *i.e.*, the lower rate = 1s. 6d. per dozen. ∴ The original price = 1s. 6d. + 3d. = 1s. 9d. per dozen. **11.** Selling price of 1 cwt. = 19d. × 112 = 2128d. = £8 17s. 4d. ∴ The gain on 1 cwt. = £8 17s. 4d. − £6 10s. = £2 7s. 4d. **12.** A packet is given for 5 coupons, so that 5 coupons = 5 cigarettes + 1 coupon. ∴ 4 coupons are worth 5 cigarettes—*i.e.*, a coupon is worth $1\frac{1}{4}$ cigarettes. Hence, $5 + 1\frac{1}{4} = 6\frac{1}{4}$ cigarettes should be sold for 1d., and ∴ $6\frac{1}{4} \times 12 = 75$ for a shilling. **13.** See correction of this example on page 708; the £29 15s. should read £29 5s., and the answer to the corrected sum is 1 sov. + 1 half-sov. + 1 crown + 1 half-crown + 1s. + 1 sixpence = £1 19s. Now, £29 5s. ÷ £1 19s. = 15. ∴ there are 15 coins of each sort.

Examples 8

1. 17948·6 + 29510 + 307 + 5400 + 729·825 = 53895·425 litres. **2.** 1·2345 + 4300 + 3529 + 71·46 = 7901·6945 sq. metres. **3.** 42 + 62·4 + 27·5 + 4200 = 4331·9 ares. **4.** 2450·4 × 63 = 154375·2 centigramme. **5.** 90 Hm. 7 Dm., etc. = 9072350 mm. This, divided by 47 mm., gives 193028 quotient, and 34 mm. remainder. Required answer is therefore 193028 times, and ·034 metre remainder. **6.** 124·305 Kg. at 25 centimes per Kg. = 3107·625 centimes = 31·07625 francs. **7.** 275 litres at 3·50 francs per litre = 275 × 3·5 = 962·5 francs = 962 fr. 50 cent. **8.** No. of sheets = 2700 mm. ÷ 1·5 mm. = 27000 ÷ 15 = 1800. **9.** 4 miles per hr. = 5 miles in $1\frac{1}{4}$ hr. ∴ I walk 8 kilo. in 75 min., *i.e.*, 1 kilo. in 75 min. ÷ 8 = 9·375 min.

Examples 9

1. 587 and 997 are primes. [745 is 5 × 149; 1073 is 29 × 37]. **2.** (i) 165 = 3 × 5 × 11; 341 = 11 × 31; 1302 = 2 × 3 × 7 × 31. There is, therefore, no common factor except unity. (ii) 373. **3.** (i) 17640, (ii) 58497, (iii) 5012280. **4.** 1 lb avoir. = 7000 gr. 1 lb. Troy = 5760 gr. The L.C.M. of 7000 gr. and 5760 gr. is found to be 144 × 7000 gr. ∴ Reqd. answer = 144 × 7000 gr. = 144 lb. Avoir. **5.** Least no. which leaves no remainder = L.C.M. of 42, 63, 81 = 1134. ∴ Least no. which leaves 40 rem. = 1134 + 40 = 1174. **6.** Req. no. = 17 eights + 17 nines = 17 × 17 = 289 pencils. **7.** Ring together after L.C.M. of 2, 3, 5, 9 seconds = 90 secs. = $1\frac{1}{2}$ min. **8.** Greatest weight of a coin = H.C.F. of 38875 gr. and 2605 gr. = 5 gr. **9.** L.C.M. of 30 in. and 33 in. = 330 in. But in this distance first man takes 11 steps and the second 10, so that they are not "in step" till they have gone 2 × 330 in. ∴ Required no. of times = 1 mile ÷ 660 ins = 96.

Examples 10

1. $\frac{13}{35}$, $\frac{8}{21}$, $\frac{11}{28}$. **2.** $\frac{46}{57}$, $\frac{31}{38}$, $\frac{97}{114}$, $\frac{81}{95}$. **3.** $\frac{31}{322}$, $\frac{41}{300}$, $\frac{23}{222}$. **4.** $11\frac{2}{35}$. **5.** $1\frac{121}{252}$. **6.** $5\frac{311}{420}$. **7.** 1. **8.** $\frac{13}{336}$. **9.** $2\frac{5}{8}$. **10.** 1. **11.** $1\frac{1}{24}$. **12.** 1. **13.** 12. **14.** $\frac{2}{3}$. **15.** $2\frac{1}{2}$.

Examples 11

1. ·524. **2.** 560 min. **3.** Share of third = $(1 - \frac{1}{4} - \frac{2}{9})$ of whole = $\frac{19}{36}$ of whole. ∴ $\frac{1}{36}$ of sum = 2s., *i.e.*, sum = 72s. = £3 12s. **4.** Half-a-crown = $\frac{5}{4}$ of the cost. ∴ Knife cost $\frac{4}{5}$ of 2s. 6d. = 2s. Hence, if the boy sells it to gain $\frac{1}{4}$ of the selling price, this 2s. will be the remaining $\frac{3}{4}$ of the selling price. Hence he must sell it for $\frac{4}{3}$ of 2s. = 2s. 8d. **5.** Since the eldest had as much as the other two together he must have had half the entire sum. The second son had $\frac{3}{8}$. ∴ Youngest had $1 - \frac{1}{2} - \frac{3}{8} = \frac{1}{8}$ of the sum. ∴ Sum the father left = 8 × £450 = £3600. **6.** Second has $\frac{5}{8}$ eldest; youngest has $\frac{5}{8}$ of this, *i.e.*, $\frac{25}{64}$ of the eldest. ∴ The eldest has a sum equal to $1 - \frac{25}{64} = \frac{39}{64}$ of his own share more than the youngest. ∴ Eldest's share = $\frac{64}{39}$ of £73 2s. 6d. = £120. The second has $\frac{5}{8}$ of £120 = £75. The third has $\frac{5}{8}$ of £75 = £46 17s. 6d. ∴ The total money = £120 + £75 + £46 17s. 6d. = £241 17s. 6d. **7.** 3·016. **8.** Between 2 and 2·15, *i.e.*, in $\frac{1}{4}$ hour he does $\frac{1}{3} - \frac{1}{4} = \frac{1}{12}$ of his journey. But at 2.15 he still has $\frac{2}{3}$ to do. This will take him $\frac{2}{3} \div \frac{1}{12} = 8$ quarter hours. He thus finishes 2 hours after 2.15, *i.e.*, at 4.15. **9.** 3 oranges = 1 orange less than half the number she had before selling to D, *i.e.*, 4 was half the number she had. She therefore sold D 5 out of the 8 she had on leaving C. Similarly, she sold C 10 out of 18 she had on leaving B; she sold B 20 out of 38 she had on leaving A; and she sold A 40 out of 78 she had at first. Thus, required number = 78. **10.** $\frac{4}{5}$ of distance gone = $\frac{1}{2}$ distance left. ∴ Distance gone = $\frac{1}{2} \times \frac{5}{4} = \frac{5}{8}$ of distance left. He must therefore have already gone $\frac{5}{13}$ of the whole distance. Now, $\frac{5}{13}$ is $(\frac{1}{2} - \frac{5}{13}) = \frac{3}{26}$ of the whole distance short of half-way. Hence, $2\frac{1}{4}$ miles = $\frac{3}{26}$ of the whole distance. ∴ Whole distance = $\frac{26}{3} \times \frac{9}{4}$ miles = $19\frac{1}{2}$ miles. ∴ Reqd. answer = $\frac{8}{13}$ of $19\frac{1}{2}$ miles = $\frac{8}{13} \times \frac{39}{2}$ = 12 miles.

[*The answers to other examples will appear in due course.*]

Continued

Continued from page 704.

AGRICULTURAL IMPLEMENT DEALERS

The mere buying and selling of implements offers scarcely sufficient scope for a really smart man. Indeed, it is doubtful whether it would yield a living at the outset. It must be supplemented by a working department in which estate engineering finds a place, or, on the other hand, the implement business may form part—as it frequently does—of a general ironmongery concern.

The implement dealer will find his work change with the recurring seasons. Stock suitable for display in May is very different from that sold in October. For all practical purposes, an agent has to be conversant with and hold stocks of four or five classes of machines.

Classes of Machines. Starting with Michaelmas, the demand will be for what are categorically classed as cultivating implements. In October he will be pushing ploughs, harrows, cultivators, scarifiers, chain harrows, hand rollers, and the like. A month or six weeks later these will give place to food-preparing implements, a class which includes such machines as chaff-cutters, turnip-cutters, oil-cake mills, corn-kibblers and grinders, root pulpers and slicers. About the same time, and right on with the new year, seeding implements will be in demand.

This carries us to March, when the agent begins to lay his plans for selling harvesting machinery, which includes grass-mowers, hay-rakes, hay-tedders and haymakers, the almost obsolete self-raking reaper, and the now universally employed self-binding harvester. Then, after harvest, there is the rather small, but always possible, chance of getting an order for a threshing plant, including an engine, the total price of which may be between £200 and £400. As, however, the makers of such plants prefer to do business direct with the purchaser, only a well-established firm of implement agents stands much chance of getting such orders.

Regular Selling Stock. Then all the year round there is the sale of dairy utensils, butter-making churns, milk separators, tinware, including milk-cans in districts in close proximity to large towns, and cheesemaking plant in others. Besides, in certain parts of England the agricultural engineer is mixed up with cider making, and in nearly all he must needs sell galvanised iron feeding-troughs, skeps, pails, etc.

It is difficult to decide with how little capital an agent can start with reasonable prospect of success. If the business is developed as one department of a more comprehensive concern, £200 would purchase a well-assorted season's stock; but to start with anything less than £500 as an independent venture in selling, repairing, and manufacturing, in even a small way, would be to court failure.

The cost of equipping a workshop in which the repairing of mowers, binders, and general implements could be carried on would run into £200, for besides such simple tools as a drilling-machine and a smithy forge, a lathe and grinding machine would be necessary, and for producing power a small oil or gas engine would be required. An implement business without a workshop department would not be practical, and the better the shop equipment the greater the prospects of success. A large part of an agent's business consists in supplying wearing parts, and in maintaining the farmers' machines in good repair. The life of a plough, for example, is likely to extend to from ten to fifteen years in the hands of a careful farmer, and during that period it is a source of revenue to the agent, if the farmer remains one of his customers.

Renewal Parts. In our estimate we have accounted for £400 of the suggested £500 capital. Some money must be sunk in a stock of renewal parts, which need not necessarily be purchased from the actual makers of the implements. Castings, of course, should be obtained at first hand, made from the original patterns, as otherwise they will not fit the old parts without a lot of fitting, which involves expense. Other wearing parts are obtainable to standard gauge from firms to be found chiefly in and around Sheffield, who specialise in such things as the sections of mower and harvester knives, malleable parts which wear out, brass bushes in which the various shafts and axles work, the fingers on the bars of mowers and harvesters, the knives of root-machines and chaff-cutters.

The Manufacture of Parts. Many parts can be made in the agent's own shops during the slack seasons—spindles for mowers and crank-pins, for example, while some of the castings can often be obtained locally and finished to gauge or template in the shop. This course does not invariably mean economies in production and extra profits, but it often pays to make up in slack times goods which could otherwise be bought as cheaply from the large

manufacturers, because thereby the services of good mechanics can be retained all the year round.

Fields of Enterprise. The workshop also enables the agent to extend his operations, and under the direction of a "live" man it affords opportunities of securing contracts which are only indirectly connected with agricultural implements.

In the present transitional stage of agricultural methods, the business in oil and petrol engines of small power offers great possibilities. A reputation for fixing small internal combustion engines is well worth winning, for there follow not only farmers' orders, but others from butchers, printers, saw-mill owners, millers, builders, and turners, to mention only half a dozen trades in which low-power engines are used.

Windmills, or, as the makers prefer to call them, wind-engines, are coming more and more into favour for pumping water, and for these the farmer and estate agent looks to the implement dealer. Each order for a windmill necessitates pipe-laying and the supplying and fixing of pumps, storage reservoirs and, at times, the sinking of wells.

Yet again, water supply in country districts is often secured by means of the hydraulic ram. Here, again, the pipe service would fall into the hands of the dealer.

Sole Agencies. To get back to the commercial side of the business, a dealer must decide whether he will secure sole agencies or transact his trade on the open system. In the former case he bargains to sell this man's ploughs and the other's mowers, and no other. In the latter he buys and sells what he chooses or his customers want. A mixed policy is usually the best course. There is little to be gained, except a bare margin of extra profit, in hampering one's self with such machines as chaff-cutters, and food-preparing machinery generally. One manufacturer's productions are about as good as another's. It adds variety to the stock to show machines by two or more makers. The same remark applies to implements of cultivation and seeding, but not to harvesting machinery. By taking up the sole agency for a binder, and even for a mower, the dealer keeps down the stock of repair parts, and is enabled to win a reputation for promptness in breakdown emergencies, which frequently occur in the harvest-field.

Finance of Implement Dealing. The dealer in agricultural implements is not at present in a very strong position. A few years ago unsuccessful efforts were made in several parts of England to form associations to prevent price-cutting, which had grown serious.

The financial practice of implement dealing is out of date. Long credit, which would not be tolerated in many other trades, is demanded by the farmer. A year is not at all uncommon; and the agent, unless well backed with capital, has seldom the ability to take the cash discounts manufacturers are ready to allow for prompt settlements. Since he cannot get payment of accounts, the dealer must perforce be in debt. The terms of trade between the manufacturers and the agents are nearly all on the basis of list prices subject to fixed discounts, which, however, vary with the price of raw materials. Thirty or thirty-five per cent. is a common gross discount for food-preparing machines; but that does not represent the profits of the business. The British farmer expects substantial discounts from makers' list prices, and the working expenses of an agent are so large that the agent is fortunate if he can make 10 per cent. profit on his capital after having allowed himself only a small sum for personal management.

ANIMAL AND BIRD DEALERS

By this heading is meant, not the sellers of farm stock and poultry, but the retailers of fancy birds and animal pets. The business is a minor one, and may be classed among those purveying luxuries. The former fact explains why so little is known about it outside the ranks of those who seek a livelihood by its agency, and the latter causes it to respond to depression and prosperity more than do those shopkeeping trades which cater to everyday wants.

The Decline of the Trade. Should the aspirant hankering after the possession of an animal and bird shop seek advice from those who have been in the trade for a quarter of a century or more, he will almost certainly receive the counsel, "Don't." A few decades ago birds were in fashion as household pets. Other interests have superseded the taste for birds of song and brilliant plumage, and from being the toys of the classes they have fallen to be the pets of the masses. This decline has made the bird and animal trade more than ever the sport of general trade depression. It also means that prices have fallen. From the frequent price of £5 to £10 the parrot has got down to 15s. to 30s. Also, the breeder and the private owner have come into direct contact more than formerly, so that the dealer has little chance of making money out of show birds and animals.

Present Condition. Yet, although the tendency of this trade for many years past has been far from encouraging, it is possible to make a livelihood in it if the district be favourable. An essential condition of profitable result is that the man who takes up the business should have a genuine love for animals and birds. Without such a love, he is certain to neglect them, and neglect means the sickness and death of his stock and pecuniary loss.

Buying Stock. Many an entrant into the trade begins business with only £25-£50 to spend, and this notwithstanding that he must pay cash down for this stock. Often the smallness of the capital is the best thing possible for the man. It prevents him from overstocking, and for an obvious reason the trade is one which should be worked upon the smallest stock possible. In the first place, the chief loss incurred in the business is by the death of stock, and the smaller the stock the smaller the risk of loss from death. In the second place, live animals are different from ordinary stock. The money which birds and animals cost in food

reduces the profit upon their sale, and the longer they remain unsold the greater is this expense.

There is no on and off season in the bird trade. It may be that occasionally—as, for example, when a dealer has developed a connection among the frequenters of a summer resort—there are a few months of the year which may be reckoned the harvest time, but the man who depends for custom upon the non-migratory residents in his neighbourhood finds his returns distributed fairly evenly over the twelve months. Exotic birds are sold in the spring and summer, and British wild birds trapped in summer and autumn sustain the business during autumn and winter. Then the return of spring sees the opening of the trade in exotics again. It would be possible, but unprofitable, to bring exotic birds into this country during the winter months. The change in climate would be too severe, and the death-rate would be high.

Wholesale Importers. The wholesale merchants through whose agency the birds, particularly foreign birds, reach the retailer, are located chiefly in our ports London and Liverpool. They do not hold general stocks all the year round. The usual custom is that every week the merchant issues a circular to his customers giving a list of the birds he has and offering them subject to being unsold upon receipt of order. Then it is a question of first come, first served. The birds are usually despatched by passenger train, and the railway companies charge rates 50 per cent. higher than those prevailing upon ordinary parcels, and assume responsibility for safe custody up to five shillings per bird. Ordinary parcel rates only may be paid if desired; but in such a case no responsibility attaches to the carriers, and most dealers find it profitable to pay the higher rate.

Sick birds may, according to the rule of the trade, be returned to the wholesale importer, who seldom refuses to accept return.

Profits. A trade with the risks and expenses which pertain to the sending of birds demands higher profits than belong to most departments of shopkeeping. It is usual to charge double cost price, but it is always well to get more when possible. One hundred per cent. on cost price may yield a living, but little more. But there are side lines which belong naturally to the trade, and these may be made to help considerably the annual balance-sheet. There is the trade in cages and aviaries. Many retailers of birds are makers of cages also. The ability to undertake the manufacture of cages is not given to every retailer of birds. It requires a deftness in wirework which one may acquire only by a practical training or a natural aptitued But anyone may at least sell the cages. They yield fair profit, seldom less than 50 per cent. on cost price, and often more. As they do not occasion the expenses necessary to the handling of live stock, they may well be sold on smaller profits.

Side Lines. The bird seed and food trade also naturally falls to the province of the retailer of birds, and returns about the same profit as cages. There are several firms who make a specialty of putting up bird food and bird medicines in convenient retail packages, and an account with one of these is all that the retailer need open in this department. Advice will often be asked regarding the care of birds and the treatment of sick birds. The dealer recommends what he has to sell, and reaps a profit thereby. Another trade is naturally allied to the selling of live birds—the stuffing of dead ones. Yet the two are found united less frequently than they ought to be. They go well together. The one supplements the other, and skill in the art of stuffing is not difficult to acquire. For information on both its technical and commercial sides, readers may refer to the chapter on TAXIDERMY, which will follow in this course.

Care of Stock. The care of stock is the most important department in the bird-dealer's business. A bird worth twenty shillings when alive is not worth twenty pence when dead, and the chief aim is a low death-rate. The birds and their cages must be kept clean; the cages should be cleaned out every other day. Care in feeding is also essential. Many dealers think it necessary to study the food of each class of bird; others, recognising that about half of the birds thrive best on canary seed and the other half on millet, feed all upon a mixture of the two. Hemp seed must be given sparingly. It is not desirable as a single diet.

Most foreign birds breed in captivity, but not many dealers adopt the breeding of exotic birds as a serious business. They prefer to turn over their stock rapidly, and regard it as the more profitable plan. Prize and show birds are also considered unprofitable as merchandise. Those who buy such birds are too expert in what prize birds ought to be and too exacting in their requirements. Also, the money sunk in prize birds per head is much more than in common varieties, and loss by death is much greater. While talking parrots fetch much more than others in which this ability is latent, few dealers set themselves to teach parrots the art of speech. It seems to require more patienc and perseverance than is possessed by the average dealer. There is no reason, however, why teaching birds to acquire linguistic ability should not be turned to more profitable account than it is.

Animals. The heading of this article was "Animal and Bird Dealers," but the treatment, so far, has concerned birds chiefly. There is reason in this. The major part of those who sell pets sell birds only, and those who deal in animals as well find birds the most important part of their business. The general trading conditions which we have recited as applying to birds refer to animals as well.

The trade in wild animals is in few hands, and while the subject might have an academic interest for the reader, it can scarcely concern him practically. There is not room in these islands for many Jamrachs.

But retailers of dogs, cats, rabbits, and other live pets, find the business not so profitable as those whose energies are chiefly occupied with

birds. Buyers are, as a rule, more critical. The breeding of dogs is often extremely profitable, and is not attended with much expense. A business which naturally springs out of the handling of animals is that of conducting an animal hospital. There are a few of these throughout the country, and, judging by appearances, nearly all are lucrative concerns. The wealthy who travel, or who migrate to the hills or the seaside annually, and who do not wish to take their pets with them, do not object to pay a good price to have these tended during their absence. The services of a man professing to make this a business are often more acceptable than those of an obliging friend who seeks no fee for acting as temporary custodian of the animals.

ART DEALERS

The trade of art dealing is, under certain circumstances, one of the most lucrative that can be followed, though in some respects there is none so precarious. With the necessary knowledge, taste, and, what is even more important, capital, the profits that can be made far surpass those made in the average business, but without all these qualifications it is practically impossible for one to succeed as an art dealer. Granted that a man has the capital, he, to be successful, must possess that inborn sense of *flair* which will enable him to differentiate between the genuine and the bogus. This cannot be learnt; it must be born in a man. And if he does not possess it, it is useless for him to contemplate becoming an art dealer.

As an instance, a certain well-known dealer has had with him for four or five years as his right-hand man one who will never be competent as a dealer. Though in close touch with hundreds of objects daily, he knows really little more than when he entered the business. In fact, he lacks the required *flair*, or instinct. This same dealer, too, has a porter who, through merely handling the objects when dusting or packing them, can tell at a glance a piece of Worcester, Sèvres, or Nankin porcelain, although he has been in the business only a year or two. Though practically an uneducated man, he has this instinct, and had he the necessary capital, would undoubtedly prove a successful dealer.

The Knowledge Necessary. The acquisition of a knowledge of the peculiarities of the different objects that may pass through his hands is the first thing that the prospective dealer has to seek. Whether he intends to become a picture dealer, printseller, or a dealer in china and furniture, the routine is the same. He may learn from books particulars regarding the lives of artists and engravers, information as to the periods of the leading craftsmen of past times, and particulars as to the foundation and distinguishing marks of the various china factories, all useful and necessary information in his business. But no amount of reading will explain to him the peculiarities of the different schools of painting, or the difference in the paste or glaze of the porcelain of one factory from that of another. This information can be obtained only by actual examination of the objects, and there is no better school than the museum. In the National Gallery, for instance, one can find pictures out of number, all of undoubted authenticity, and splendid examples of each master's work. And in the South Kensington Museum or the Wallace Collection will be found specimens of every kind of furniture, china, or art object in which a dealer is likely to trade.

Experience and foresight are two necessary qualities. The former can only be gained by time, and the latter by watching the public taste. It is necessary not only to know what the public want, but one must also learn to know what the public will want ten years hence. A remarkable instance of the lack of this last quality can be given. When the Pre-Raphaelite movement was in its infancy, perhaps the most famous firm of art dealers in the world would have nothing to do with its productions. In fact, they ignored the artists and discouraged all intending purchasers. Time has proved how wrong their estimation was.

The Auction-room as a School. Besides the galleries, a splendid school is Messrs. Christie, Manson & Woods' famous rooms in King Street, St. James's, London. There, during a season, hundreds of pictures, engravings, and art objects of every class and quality come up for sale, and by constant attendance one may learn what class of works are in demand and which are in disfavour. The prices obtained at these rooms, however, must not be too carefully noted, for many things have to be taken into consideration. If the object sold comes from a collection of repute, it is practically certain to fetch a good figure, merely owing to the prestige of its owner; whilst a similar object, sold with little or no pedigree, may not fetch more than a tithe of the sum

Having gained the necessary knowledge, especially where pictures are concerned, the dealer must have the courage of his convictions. If his judgment tells him a certain artist's work is really good, he must not be affected by outside influences. The majority of his rivals are like sheep following each other's lead, and have little ability to recognise real talent. This foresight is really the faculty of applying experience to present circumstances, or in other words, discerning qualities which are bound to make the picture a saleable object. In pictures there should be something besides sentiment. There should be a strength, a force in the design which displays the handiwork of a capable artist. Other points must be noted by the dealer, which are that each work purchased is by the artist assigned to it, that it is not an early and unimportant canvas touched up to give it an increased value. Pedigree plays a large part in the value of a picture, and one should be ever wary of acquiring a picture of which the past history is at all doubtful.

Engravings. As regards engravings, Christie's sales are a splendid opportunity for one to come into touch with the work of the leading English and Continental engravers. For real study, however, the Print Room at the British

Museum cannot be surpassed. There can be found engravings of every period and every state. State is everything in a print, and unless one can distinguish one state from another, it is impossible ever to attempt to deal in prints. Engravings, more especially of the eighteenth-century English School, form a splendid example of the flights of Fashion. There is no possible reason why such prints should realise the huge sums which are given for them at present, for they are not unique, like a fine picture. Let some other copies of one of them come to light, and its rarity is gone, and the dealer is left with a print for which he can never hope to get the money paid. At present certain schools of engravings are altogether ignored, though the work is undoubtedly superior to that done by the later men; but even if a man has scores of these prints in his shop, he may not be able to sell them, although it is an absolute certainty that they will one day regain their lost favour and return him ample interest on his money.

Art Furniture and China. To deal in furniture, china, and objects of art generally, requires perhaps as much knowledge as any branch of dealing, besides much taste and decorative instinct. Every year fashion changes, and what may be in demand one season may be unsaleable the next, and this has to be guarded against. Really good furniture by the leading masters of the craft will never depreciate. But there are certain styles which, with the taste of the moment, rise enormously in value, and then as suddenly decline.

At the South Kensington Museum and the Wallace Collection magnificent examples of the work of the leading English and foreign masters will be found, and there are no better schools in which to learn. Study each piece and note its peculiarities. Notice the workmanship, the material, and finish. In this way only can the requisite knowledge be obtained; and in time the earnest student will find himself unconsciously becoming familiar with the distinguishing features of each maker and period. Many items at the South Kensington Museum are priced, but these prices should be ignored, as they are no guide to valuation, for frequently their value since the price was affixed has, through change of fashion, largely increased or decreased. In the space of ten years a certain class of furniture may jump into favour, reach enormous prices, and just as suddenly fall into disfavour, simply owing to fashion. It is this changeableness that forms one of the pitfalls of the dealer. To be successful one must keep in touch with the market. Buy that for which you know there is a permanent demand, and leave severely alone anything that is likely to have but a fleeting popularity.

The same remarks apply to the dealer in porcelain and pottery. Study the different factories at the museums. Commence with the English, then continue with the Continental, and conclude with the Oriental factories. The first is the most desirable. It is the easiest to learn, and lacks many of the complications that will be found in the other branches. All china, both English and foreign, is imitated, and only by long practice can the beginner learn to tell the real from the fake. Many English factories reproduce vases and figures in exact facsimile with those issued by the same factory a hundred years before, and though many dealers stock these reproductions, they should be bought and sold on the distinct understanding that they are not original pieces. A splendid school in which to learn the value of English china, furniture, and bric-à-brac are the rooms of such firms as Messrs. Puttick & Simpson, Messrs. Sotheby, Wilkinson & Hodge, and Messrs. Glendining, in London. At these rooms one will find on occasion choice little representative collections realising prices more in accordance with their market value.

Old Silver-plate. The demand for old silver-plate has of recent years made it a most profitable branch of art dealing. But here, too, one needs to be thoroughly in touch with the principal makers of each country and period, their distinguishing features, besides learning all the mysteries of hall-marks and date letters. These latter can be learnt from books, but no amount of reading can teach a man the difference between the silver of Tudor and Stuart periods, or the characteristics of the work of the early silversmiths. This subject, too, can be studied at museums. In fact, the museum should be the home of the prospective dealer. Practically everything he requires can be found at the South Kensington and British Museums.

Personal Relics. Relics of famous people in history are largely dealt in, but no objects are so liable to fluctuation. Personal relics with authentic pedigrees will realise any sum, but only experience will teach the sum to which one should go when acquiring them. Present circumstances are the great factor in affecting their value. The Nelson Centenary, for instance, simply flooded the market with relics both of intimate and slight connection with the famous admiral, and remarkable prices were paid for certain objects. Eventually, however, the market got overstocked, and a slump is practically inevitable. Relics should not only be considered from the point of view of relics, but they should also be viewed from an artistic point of view. A bust of Nelson, for instance, may realise a good price because it is a memento of a great man, or because it is a fine example of the art of sculpture. It is this broad view that the dealer should endeavour to acquire.

In conclusion it cannot be too firmly impressed that art dealing needs much perseverance and patience. It is not like an ordinary trade, where in a few months the whole stock has been sold and replaced. Many things a dealer may buy may remain in his shop for years, and it is this fact which makes capital so indispensable. One must be able to sink a large sum without any absolute certainty as to when it will be returned. Some things are, of course, bought and sold within twenty-four hours, but against such instances there may be a score of objects

purchased for which no immediate buyer can be found.

Imitation Antiques. In no trade, unfortunately, is there so much dishonesty as in that connected with art objects and their sale, and at the very commencement of his career the prospective art dealer is faced with a difficult problem which he is compelled to solve. Does he intend to sell genuine objects only or does he intend to include in his stock items of a doubtful authenticity, and trust to his being able to sell them to gullible collectors as the real thing? There are those who say that art dealing and honesty cannot go together. But this is not true; there are plenty of dealers upon whose integrity one can place absolute reliance. If when starting business you sternly set your face against the fake, and refuse to have anything of the sort in your shop, it is bound to pay you in the end. Though you may by a trifling mis-statement make a few pounds, you may feel almost sure that if your customer discovers that he has been cheated he will never deal with you again; whilst once you get a name for straight and honest dealing you will have little difficulty in getting together a clientèle of a permanent character.

Of the text-books that are almost indispensable the following can be procured with the knowledge that they are reliable:

Bryan's "Dictionary of Artists and Engravers," Whitman's "The Print Collectors' Handbook," Chaeffer's "Marks on Old China," Cripps' "Old Silver-plate," Macquoid's "History of English Furniture," the books of Chippendale, Sheraton, and other masters.

In fact, as regards handbooks there is no end, though the average cheap little text-book so frequently published at present is by no means always reliable.

But no opportunity must be missed of increasing the reference library, and as new editions and new books appear they should, if one wishes to keep in touch with art, undoubtedly be acquired.

ARTISTS' MATERIAL DEALERS

The retailing of artists' materials is a trade which can scarcely stand alone. It is not sufficiently large, and is usually added to some other shopkeeping business—such as that of a stationer and print-seller, a painter and paperhanger, an ironmonger, and we even remember to have seen a chemist who handled artists' colours as a side line.

Time was when technical knowledge of colour grinding and mixing was essential to the successful dealer in artists' materials. These were the days before the collapsible tube had usurped the place of the hog's bladder as the receptacle of mixed paints. Now the manufacturers or wholesale merchants supply everything packed in convenient retail packages, and the retailer need have no special technical acquaintance with the wares he handles.

Ease of Entering the Trade. The trade is one in which little bad stock accumulates. There is therefore little loss on this score. Anyone thinking of embarking on the sale of artists' materials has only to put himself into communication with one of the large wholesale houses and he will be supplied with everything he wants. He need not open more than one account.

The amount required to add an artists' materials department to any business may vary from £20 to £100. Not more than the latter sum should be expended until a firm connection has been established. The keeping of stock would be attended with greater difficulty were it not that here also the manufacturer comes to the help of the retailer and provides him with a cabinet specially fitted for the stocking of the many oddments which artists require. The accompanying illustration shows one of these stock cases. This particular one is by Messrs. Winsor and Newton, London, but all other good houses supply stock cases.

The case illustrated is for the cautious man who is content to spend £25 on a stock of artists' materials. The cost is £18, with the glazed top compartment fitted with a representative assortment of the necessary sundries. The size of the case is 41 in. long, 30 in. wide, and 55 in. high at the back. The gross retail value of the articles which it contains is about £18, so that the man who has sold the contents with which he started, or their equivalent, has earned the case.

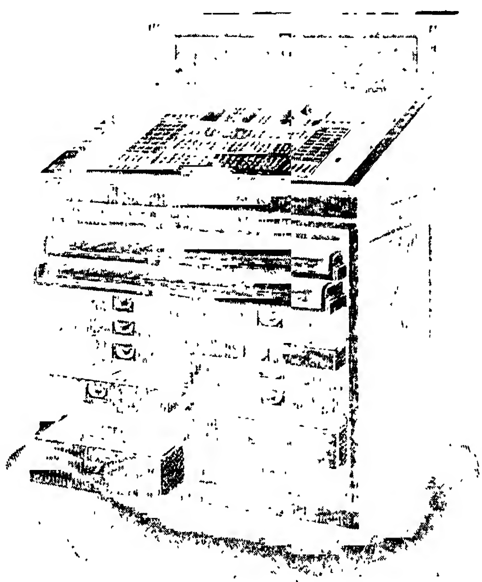
Nature of Stock. The stock contained in such a case when purchased comprises a good assortment of cake, moist, and oil colours, water-colours, liquids, oils and varnishes, pencils, chalks, and crayons, and brushes for oil and water painting. Besides these things the retailer must purchase canvases, easels, drawing-boards, T and set squares, paper blocks, and sketch-books. The £7 left after spending £18 out of the allotted £25 upon the fitted case will furnish a sufficient assortment of all these. Then the would-be artists' colourman is ready to inform brush wielders in his neighbourhood that he is ready for their assault.

Profits. The profits carried by goods such as we are discussing is in the region of 33⅓ per cent. on retail price, or 50 per cent. on cost price. That is to say, that the 1s. article costs 8s. per dozen, and things at other prices proportionate to this profit. To some traders in other branches of shopkeeping the profits may seem high, but they are not more than remunerative. The dealer in artists' materials may turn over the worth of his stock only once a year. The man who enters the trade thinking to make a connection for himself by giving part of his fourpence in the shilling to the public makes a great mistake. He will find that the trade is far too slow to make cutting tactics profitable. It is far more necessary to give the goods wanted exact to requirements than it is to sell 5 per cent. cheaper. In other words, quality is far more important than price. But, however much he may try to maintain catalogue prices, he will find it impossible in every case. The casual customer may be made

to pay them, but professional artists have succeeded in instituting the practice of discount allowances, varying with the nature and price of the articles, ranging up to 25 per cent. Thus, when requested, the dealer must allow these artists discounts.

The terms of payment usual in the artists' material trade depend upon the district. Accounts are usually journey accounts collected by the commercial travellers. This means three, four, or six months, according to the frequency of the travellers' visits to the town where the retailer resides. Some districts will not stand more than semi-annual journeys.

A Department Worth Pushing. The selling of artists' colours proper is a trade where enterprise cannot carry a man to the high success possible of achievement in many other branches of shopkeeping. The consumption of such goods in any district is strictly limited, and no amount of advertising or other methods of self-assertion on the part of the retailer will appreciably augment the volume of trade of the district. But one branch of the business which can be extended is that of supplying artists' materials for students and children. A wave of desire for culture in the several grooves of art is at present inundating our country, and, indeed, the world, as never before, and is a field prepared for the artists' colourman.



STOCK CASE FOR ARTISTS' MATERIALS

Students' colours, as they are called, are not of the quality necessary for the work of experienced artists. The student's efforts are not intended to be permanent. Indeed, as he attains experience and ability he frequently finds the records of his early clumsiness far too permanent to be agreeable. Thus, students colour-boxes are inexpensive. They are more profitable than regular goods, and 40 per cent., and sometimes even 50 per cent., of the retail price is profit. Formerly, manufacturers of the first rank held aloof from this department, believing that their reputation as makers of high qualities would suffer if they descended to the qualities necessary for cheap colours. But wiser counsels now prevail, and the best firms in the trade no longer hesitate to attach their names to materials for the use of the student and schoolboy artist.

Other Possible Departments. Students have need of copies from which to work and the dealers find this a profitable department. A drawing copy, costing sixpence, or sometimes only half that amount, may be hired at a penny a week, and if the hirer forgets to return it for a few weeks, the price paid for its use may represent the price of the article. For coloured reproductions let out as copies the price i higher, usually threepence a week for good copies, and their cost seldom exceeds a half-crown. The hire of copies is a department which ought to be encouraged. Payment is in pence, but pence mak pounds.

Many colourmen share in the present enormous trade in picture postcards, which yield from 50 to 150 per cent. profit. The department yields some soiled stock, which, however, can usually be cleared. In any event, the profits can stand some loss of this nature.

The department of art dealing — that is, in pictures and prints—falls naturally to the share of the artists' colourman. It h s been treated in the article immediately preceding this one.

Tools and material for clay and wax modelling, for poker-work, for fret-saw work, and designs for amateurs in these arts, are also proper branches for cultivation by the artists' colourman. They require only moderate outlay for stock, and yield about the same rate of profits as pertain to artists' materials.

Stock of a more expensive nature may be attempted in drawing and mathematical instruments. Some localities—as, for instance, those in proximity to a technical school, engineering works, and architects' offices—are specially favourable for such a trade.

Selling on Commission. It frequently happens that the artist customers request the dealer in materials to undertake the sale of their work. Sometimes this is embarrassing; more often it is welcome, as it enables the retailer, without the capital necessary for the purchase of such things, to show them. Customers' work should not be purchased. It may be shown with an understanding of commission in the event of sale. No definite rule can be laid down regarding commissions in such cases. It varies between 10 and 50 per cent., its size usually being in inverse ratio to the prominence of the artist and the quality of the work.

Continued

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GEOLOGY
3
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ROCKS AND THEIR CHARACTERISTICS

The Geologist's Equipment. Classification of Rocks. The Two Great Divisions—Igneous or Crystalline, and Sedimentary or Stratified Rocks

By W. E. GARRETT FISHER

WE made acquaintance in the last chapter with the chief minerals of which the rocks of the earth's crust are composed. We have now to study those rocks themselves. They are divided into three main classes: *igneous* rocks, *sedimentary* rocks, and *metamorphic* rocks.

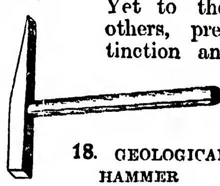
What is a Rock? In the first place, the student must disabuse his mind of the ideas commonly attached to the word *rock*. Ordinary language associates the idea of hardness with a rock. Geology takes no account of such a qualification. If the student looks back to the definition of a rock given in the last chapter he will see that it applies to all the types of matter which are to be found naturally existing in the crust of the earth. The bed of pebbles left on the convex side of a river bend, the great masses of loose sand which compose the sea-beach or the desert of the Sahara, the lumps of coal in the domestic scuttle, the clay and loam in our garden beds, the stone flags of the street pavements, the precipitous granite cliffs of Cornwall and the chalky heights of Beachy Head, are all equally rocks in the geological sense of the word. There is not even any scientific distinction between a *mineral* and a *rock*. Calcium carbonate is a mineral if we consider a single crystal of Iceland spar, a rock if we go to Carrara and look at the gigantic masses of marble of which the hills are there composed. Salt is a mineral in our salt-cellars, a rock when we think of the great beds of rock-salt which underlie parts of Cheshire. But, as a rule, a rock is composed of more than one mineral, and the study of mineralogy is thus a necessary preliminary to that wider branch of geology which deals with the rocks of which the earth's crust is variously built up.

19. PETERHEAD GRANITE, POLISHED

How Rocks are Studied. Rocks differ so widely in character that at first sight it might seem hopeless to devise any method of *classification* which should include them all under any moderate number of heads. The beginner sees little in common between sea-sand and a piece of flint, the columnar basalts of Staffa and the clay of a newly ploughed field, the tailor's French chalk and the coal in the grate.

17. MICACEOUS SANDSTONE FROM COAL MEASURES, BURNLEY, LANCASHIRE

Yet to the geologist these rocks, like all others, present well-marked points of distinction and similarity, according to which they can be arranged in a very small number of classes. He is guided by various considerations. First comes the *structure* of a rock under examination, as visible to the naked eye (*macroscopic*), or to the eye aided by lenses (*microscopic*). Then the *chemical composition* has to be investigated. Lastly comes the manner in which the *rock-masses* are arranged in Nature. All these ways of looking at rocks afford a clue to their classification, and throw light upon the history of the earth.



18. GEOLOGICAL HAMMER

The Geologist's Tools. The geologist in the field, armed with such tools as he can conveniently carry, aims chiefly at studying the *macroscopic* characters of the rocks with which he meets. These tools include a geological *hammer* [18], with its head prolonged into a chisel edge at the back, used for chopping off fragments of rocks, and so finding out what their internal appearance is—this often differs considerably from the appearance of the outside, which has been exposed to all atmospheric changes and has weathered into a modified form. To this hammer, the geologist's chief instrument, he adds a *pocket-lens*, a *knife* with a hard steel blade for scratching rocks, a *magnet*, and a vial of dilute *acid*—usually hydrochloric acid or spirits of salt (H Cl). With these instruments

20. BELEMNITES FROM THE LOWER LIAS.
Remains of internal bones of extinct cuttlefish

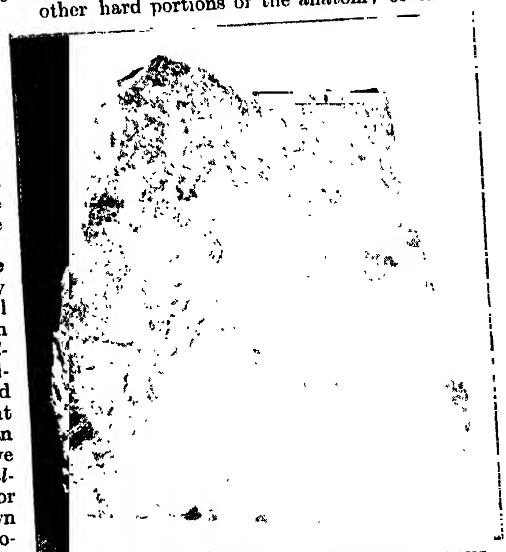
he can generally make a rough guess at the nature of any rock which he is likely to meet, and can collect specimens for the more detailed analysis of the laboratory. In addition, he carries a map of the district which he is examining, on the largest convenient scale—the Ordnance Survey sheets, one inch and six inches to the mile, are the best for this country. With the aid of a pocket *compass* and a *clinometer* [59, page 803], or instrument for measuring slopes, he can orient himself in the field and calculate the *dip*, or angle, at which the beds of rock are inclined to the level surface. We shall see later on how these latter instruments are used; they belong to the wider study of *geotectonics*, or the fashion in which the crust is built up of the rocks which we have first to question of their individual structure.

Classification of Rocks. The *system of classification* which is now universally adopted depends upon a natural distinction between the ways in which the two main classes of rocks came into existence, which has been worked out by the labour of several generations of patient students of the rocks, both in small specimens and in the great masses of Nature. We can but give here the briefest sketch of the conclusions which were thus reached.

Crystalline and Non-crystalline Rocks. If the student has access to any small collection of rock specimens, he will speedily notice one great distinction between them. Some of them show a distinct *crystalline* structure—that is, they consist of well-marked crystals of all sorts and sizes, held together by a more or less abundant cement or paste. Ordinary granite [19] affords an admirable example. Other rocks, again, have no such structure, but consist of *non-crystalline* particles held together by a cement, or packed so closely as to adhere by their own cohesion. Sandstone [17], flint, and conglomerate or pudding-stone afford good instances. Sometimes the crystals of which a rock is composed are so tiny that they can only be recognised by a microscope. But it is generally safe to say that any given specimen of rock is either crystalline or non-crystalline, and this distinction affords us the first possibility of classification.

Stratified and Unstratified Rocks. The second principle of rock classification must be studied in the field. If the student will visit a quarry or railway cutting, where he can see below the normal surface of the ground, he will soon notice a well-marked difference between various kinds of rocks. Some rocks are always arranged in distinct layers or beds parallel to one another—though not necessarily parallel to the surface of the ground—which are known as *strata*. These may be compared to the bricks in the work of a house. These strata [23] may be seen in a chalk pit, or where the railway runs through banks of sandstone, or on the seashore in the face of the cliffs along the greater part of the South Coast. But they will be vainly sought in a granite or marble quarry, or where the sea breaks, as in Cornwall or North-east Scotland, against precipices of living granite. The existence or non-existence of these layers in a rock afford another basis of classification into *stratified* and *unstratified* rocks.

Fossiliferous and Non-Fossiliferous Rocks. The third line on which we may draw our classification is that of the presence or absence of organic relics or *fossils* in a rock. Some rocks, like chalk and coal, are composed almost entirely of such organic remains, though they may, as in chalk, be only visible through a microscope, or, as in coal, be so thoroughly altered that their organic nature is only evident in exceptional cases. It is on the skeletons and bones, shells and teeth [20 and 21], and other hard portions of the anatomy of extinct



21. FOSSIL FISH FROM THE CRETACEOUS ROCKS, MOUNT LEBANON

animals thus preserved in the heart of the rocks that we depend for nearly all our knowledge of the history of life upon the earth. We shall see later how they came there. Just now it is enough to observe that it is only in certain kinds of rock that these fossils are ever found, and so we may make a third distinction between *fossiliferous* and *non-fossiliferous* rocks.

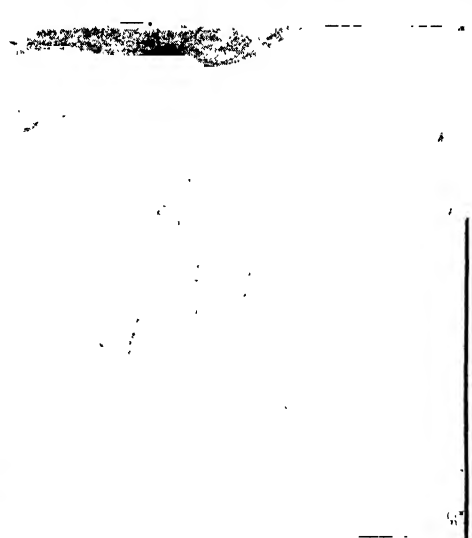
Now, if we study all the rock specimens that we can obtain in the light of these three different principles, a very curious and interesting fact emerges from obscurity. The three methods of classification all lead to the same result. With certain exceptions, which have led to the establishment of a third intermediate class, we find that a rock which is crystalline is also unstratified, and contains no fossils or relics of organic life. A stratified rock is almost always non-crystalline, though there are exceptions to this rule, which we shall encounter later, and we may expect to find organic remains in it, though it must be understood that by no means all stratified rocks are fossiliferous. Lastly, if we find a tiny specimen of rock which contains a fossil, we may predict almost with certainty that the rock from which it came is non-crystalline in structure, and arranged in layers or strata.

Thus, we have now arrived at two great main classes into which rocks may be divided:

1. Crystalline, unstratified, non-fossiliferous.
2. Non-crystalline, stratified, fossiliferous.

Igneous Rocks. The names usually given to these families are derived from a consideration of the manner in which they were formed. This is not difficult, even for the beginner, to perceive. We know, from physical science [see course on PHYSICS] that crystals are formed when a body which has been molten or dissolved solidifies. Consequently, we say at once that the first class, or crystalline rocks, must once have been molten, since the only possible solvent (water) has little or no action upon them. These rocks, in fact, are all the product of something akin to what we now know in a degenerate form as volcanic action; they must have been poured forth from the earth's interior in a liquid form, and have solidified in the place where we now find them. This also explains why they are not arranged in strata, any more than pig-iron or the slag of the blast-furnace, and why they contain no relics of organic life. These rocks, then, are usually called *igneous*, as having their origin in fire, or *eruptive*. We shall use the former term.

Sedimentary Rocks. The stratified rocks must have been produced in a different fashion. We can see how it was if we take a slab of sandstone, with its distinct beds or layers, and compare it with the sand of the seashore. The only way in which sand can be arranged in regular strata is by the action of water. The winds and tides churn it up till it floats for a while, then it gradually settles down and is deposited as a layer or stratum on the ocean bed. Another layer is deposited on that, and then another, till the first layers have sunk so far that the pressure of the sand and the ocean above consolidates them into a soft kind of rock. Meantime the living creatures in the sea have been dying and sinking down into the soft sand, where their perishable part decays and the hard part is left, to reappear as a fossil in the sandstone of a future age. Wherever there is a piece of water that is sometimes comparatively quiet this action must go on. When the water is disturbed, it sweeps up particles of sand or clay or earth; when it is quieter, they are dropped as a layer of practically equal thickness all over the bed. The sea, with its winds and tides; lakes, with their periodical storms; rivers, which run faster and fuller at one season than at another — all contribute to the formation of stratified rocks. And since these rocks all originate from hardened sediments, the name usually chosen to describe them is *sedimentary*.



22. GEOLOGICAL STRATA

Metamorphic Rocks. There is a third class of rocks, which is due to the fact that the original formations have been altered by various agencies. Sedimentary rocks may have been baked or even melted by later heat, like marble, which is merely limestone crystallised in solidifying under pressure. Igneous rocks may have obtained a falsely stratified structure, in conquence of pressure. Thus we find many rocks, of which the Gneisses and Schists are the best examples, and which seem to form a class intermediate between the other two. These are called *metamorphic* rocks, since they have been *metamorphosed* or changed from their original nature.

The igneous rocks are the oldest. The sedimentary rocks were formed from them by their gradual attrition to dust by natural processes of weathering, and the new manufacture of this dust into sedimentary rocks by water. Thus, the igneous rocks are also called *primitive*, and the sedimentary and metamorphic rocks *secondary* or *derivative*.

Continued

LATIN–ENGLISH–FRENCH

Latin and English by G. K. Hibbert, M.A.; French by Louis A. Barbé, B.A., French Master at the Glasgow Academy

Group 18
LANGUAGES
6
Continued from page 780

LATIN Continued from page 755 By Gerald K. Hibbert, M.A.

SECTION I. GRAMMAR.

Anomalous Verbs are verbs that do not form all their parts according to rule. The following are the most common:

Possum (*Pote sum*) = I am able; *Volo* = I wish; *Nolo* (*Ne-volo*) = I am unwilling; *Malo* (*Magis-volo*) = I prefer; *Fero* = I bear; *Fio* = I am made, I become (used as the passive of *Facio*, I make); *Eo* = I go; *Queo* and *Nequeo* = I can and I cannot; *Edo* = I eat.

Scheme of Conjugation.

INDICATIVE MOOD.

Present.

	Singular.	*Plural.*
1.	possum	possumus
2.	potes	potestis
3.	potest	possunt
1.	volo	volumus
2.	vis	vultis
3.	vult	volunt
1.	nolo	nolumus
2.	nonvis	nonvultis
3.	nonvult	nolunt
1.	malo	malumus
2.	mavis	mavultis
3.	mavult	malunt
1.	fero	ferimus
2.	fers	fertis
3.	fert	ferunt
1.	fio	—
2.	fis	—
3.	fit	fiunt
1.	eo	imus
2.	is	itis
3.	it	eunt

Future Simple.

Pot- ..	ero	eris	erit	erimus	eritis	erunt
Vol-, Nol-, Mal-, Fer-, Fi-	am	es	et	emus	etis	ent
I- ..	bo	bis	bit	bimus	bitis	bunt

Imperfect.

Pot- ..	eram	eras	erat	eramus	eratis	erant
Vole-, Nole-, Male-, Fere-, Fie-, I-	bam	bas	bat	bamus	batis	bant

Perfect, Future Perfect, and Pluperfect.

Potu-, Volu-, Nolu-, Malu-, Tul-, —— Iv-

1.	i	isti	it	imus	istis	erunt *or* ērĕ
2.	ero	eris	erit	erimus	eritis	erunt
3.	eram	eras	erat	eramus	eratis	erant

SUBJUNCTIVE MOOD.

Present.

Poss-, Vel-, Nol-, Mal-	im	is	it	imus	itis	int
Fer-, Fi-, E-	am	as	at	amus	atis	ant

Imperfect.

Poss-, Vell-, Noll-, Mall-, Ferr-, Fier-, Ir-	em	es	et	emus	etis	ent

Perfect and Pluperfect.

Potu-, Volu-, Nolu-, Malu-, Tul-, —— Iv-

1.	erim	eris	erit	erimus	eritis	erint
2.	issem	isses	isset	issemus	issetis	issent

IMPERATIVE MOOD.

Possum, Volo, Malo, have none.

Present.		*Future.*		
2nd Sing.	*2nd Pl.*	*2nd Sing.*	*2nd Pl.*	*3rd Pl.*
noli	nolite	nolito	nolitote	nolunto
fer	ferte	ferto	fertote	ferunto
fi	fite	—	—	—
i	ite	ito	itote	eunto

INFINITIVE MOOD.

Present.	*Pres. ptc.*	*Supines.*
posse	potens (used as adj. = powerful)	—
velle	volens	—
nolle	nolens	—
malle	—	—
ferre	ferens	latum, latu
fieri	—	—
ire	iens (*genitive* euntis)	itum, itu

Perfect Participle Passive.

Fio and *Fero* have perf. ptc. pass. *factus* and *latus*. *Factus* is used with *sum*, etc., to form the perfect tenses of *Fio*.

Feror (passive of fero) has pres. indic.: 2. ferris. 3. fertur.

Queo and *Nequeo*: Conjugated like *Eo*.

Edo (I eat) often changes some of its forms:

Ind. Pres. 2nd Pers. Sing.	*Ind. Pres.* 3rd Pers. Sing.
edis or es	edit or est

Infin.
edere or esse

Deponent Verbs. These are chiefly passive in form, but active in meaning—*e.g.*, *venor, venari* = to hunt; *utor, uti* = to use. They are found in each of the four conjugations. They are conjugated like the passive voice of a verb of the same conjugation: thus, *Venor* (like *amor*), *venari, venatus sum.* In the infinitive, however, they combine active and passive forms—*e.g.*, *Utor*:

Pres. infin.	uti, *to use*
Perf. infin.	usus esse
Fut. infin.	usurus esse
Supines.	usum, usu
Pres. ptc.	utens, *using*
Perf. ptc.	usus, *having used.*
Fut. ptc.	usurus
Gerunds.	utendum, -i, -o
Gerundive.	utendus

The fact of their having a perfect participle with an active meaning makes them very useful for translating the English "having used," "having hunted," etc. Thus, for "having spoken thus, the queen died," if we use the deponent *loquor, loqui, locutus* for "to speak," we can say *Ita locuta, regina mortua est.*" But if we used "*dico*" for "to speak," we could not use "*dictus*," which means "having been spoken." We should then have to say either (1) *his dictis* (these things having been spoken, abl. abs.) regina mortua est; or (2) *quum ita dixisset*, regina mortua est.

Semi-deponent Verbs. A few verbs have an active present, and a perfect of passive form; these are called "semi-, or half-deponents":

Audeo, *I dare*	*Perf.* ausus sum, *I dared*
Fido, *I trust*	,, fisus sum, *I trusted*
Gaudeo, *I rejoice*	,, gavisus sum, *I rejoiced*
Soleo, *I am wont*	,, solitus sum, *I was wont*

Section II. SYNTAX.

The Dative Case. 1. The dative is often used after the gerundive ptc. in —*dus* (and sometimes after other passive participles) where we should expect the ablative of the agent with the prep. *ab*—*e.g.*, *Hoc mihi faciendum est* = this is to be done (must be done) by me.

2. Predicative dative: that which a thing or person serves as, or occasions; much used with *sum, do, duco*, and (especially with military terms, *auxilio, praesidio, subsidio*) with verbs of motion—*e.g.*:

Quinque cohortes castris *praesidio* reliquit.
He left five cohorts as a guard to the camp.
Quae res *saluti nobis fuit.*
Which thing was for a safety to us—*i.e.*, saved us.
Ipse sibi *odio* erit.
He will be an object of hatred to himself; *lit.*, he will be for a hatred.
Impedimento esse = to be a hindrance.
Detrimento esse = to be hurtful, etc.

3. The dative is sometimes used where we should use a possessive pronoun or the genitive, to give greater emphasis to the person mentioned: *Tum Pompeio ad pedes se projecerunt* = then they threw themselves at Pompey's feet.

4. The dative is used after several verbs: With *sum* it denotes possession—sunt nobis mitia poma = we have mellow apples. All the compounds of *sum* (except *possum*) take a dative.

Verbs signifying to Aid, Favour, Obey, Please, Profit, Injure, Oppose, Displease, Command, Persuade, Trust, Spare, Envy, Be angry, etc., take the dative, because they are really intransitive—*e.g.*, *Parce pio generi* = spare a pious race, *lit.*, "be sparing to."

[Although *Impero* (I command) takes a dative, *Jubeo* (I order) takes the acc.]

These verbs that take a dative cannot be used personally in the passive, but only impersonally—*e.g.*, *mihi persuasum est* = I have been persuaded, *lit.*, it has been persuaded to me.

A few impersonal verbs take a dative: *libet* (it pleases), *licet* (it is lawful), *accidit* (it happens), etc.—*e.g.* *libet mihi* = I am pleased; *lit.*, it is pleasing to me.

The Genitive Case. This denotes:
1. Possession: this is the simplest and most natural use of the genitive—*Cæsaris uxor* = Cæsar's wife.

The gen. sing. of a substantive is often used as a predicate with a copulative verb, to denote such English ideas as Nature, Token, Function, Duty, Part, Mark, etc.—*e.g.*, *Sapientis est tempori cedere* = it is (the mark) of a wise man to yield to circumstances. *Cujusvis* (gen. of *quivis*) *hominis est errare* = any man may err, it is (of the nature) of any man to err.

2. The relation of whole to part: Partitive Genitive—*e.g.*, *multi vestrum* = many of you. *Fortissimus Græcorum* = the bravest of the Greeks. *Duo horum* = two of these. Often used after the neut. sing. of adjectives and pronouns expressing quantity or degree, and with *nihil* (nothing), *satis* (enough), *parum* (too little)—*e.g.*, *parum prudentiae* = too little prudence. *Aliquid pulchri* (something beautiful); *quid novi*? (what news?).

Also used after some adverbs, *quo, eo, tum, ubi*, etc.—*e.g.*, *ubi gentium* = where in the world? *lit.*, where of nations?; *eo miserarium* = to such a pitch of misery; and even *ad id temporis*, to that point of time.

Note. (*a*) The whole of the city = *tota urbs* (not *totum urbis*); all of us = *nos omnes*—*i.e.*, we all. For in these instances we are not dealing with a part.

(*b*) It is equally good Latin to say "*viginti e suis servis misit*" as to say "*viginti servorum misit.*"

3. Quality or Definition. This is very like the ablative of quality, and the substantive

in the genitive is *always* accompanied by an adjective: *homo infimi generis* = a man of the lowest race; *vir summae fortitudinis* = a man of the highest courage; *puer sedecim annorum*, = a boy of sixteen years.

4. Price. Used especially with verbs of Valuing and Esteeming; confined to *pluris*, *minoris*, *tanti*, *quanti* (and their compounds), *magni*, *maximi*, *parvi*, *minimi* (probably through confusion with the old locative, which was the case used in expressions of value)—*e.g.*, *Parvi sunt foris arma, nisi est consilium domi* = of little value are arms abroad, unless there is a policy at home. [An old form *nihili* is used in this connection.]

5. The genitive is used after verbs and adjectives signifying power and impotence, innocence, condemnation, acquittal, memory and forgetfulness, and compassion—*e.g.*, *Parricidii eum incusat* = he taxes him with parricide. *Alii reminiscentes veteris famae, aetatis miserabantur* = others remembering their former renown, pitied their age. *Capitis* (or *Capite*) *damnatus est* = he was condemned to death.

[For the genitive of the object exciting mental emotion after certain Impersonal Verbs, see next lesson.]

Subjective Genitive and Objective Genitive. Such a phrase as "the love of God," is capable of two meanings. (1) God's love for us, in which case "of God" is subjective genitive; (2) Our love for God, when "God" is objective genitive. In other words, if the genitive represents the subject of a verb it is subjective; if it represents the object, it is objective. Both of these genitives may be combined in a single phrase: *Helvetiorum injuriae populi Romani* = the wrongs done by the Helvetii (subjective) to the Roman people (objective).

Sentences to be turned into Latin.

[There are no actual words for Yes and No in Latin. An affirmative answer is expressed by *etiam*, *ita*, *factum*, *vero*, *verum*, *sane*, *ita vero*, *ita est*, *sane quidem*, etc., or by the proper pronoun, as *ego vero*; or by the verb repeated in the proper person—*e.g.*, *sentio*. A negative answer is expressed by *non minime*, *minime vero*; or with the pronoun, *minime ego quidem*; or with the verb, *non sentio*. When the contrary is asserted by way of reply, we have *immo*, *immo vero*, "No, on the other hand," "Nay rather."]

1. Do you think (begin the question with Num) God to be like me (genitive, after *similis*), or you? Certainly you do not think so. What then? Am I to call the sun or the moon or the sky God? No, assuredly not.

2. Why do you not enjoy what you have bought (say "the bought things," perf. ptc. pass. of *emo*)? Because I have bought them very dear.

3. I was persuaded to remain ten days at Cicero's house.

4. What is harder than a rock? What is softer than a wave?

5. He had come to such a pitch of boldness that (*ut*) he was unwilling to obey the general.

6. Always in a State those who have no wealth (say, those to whom there are no resources) envy the good (citizens).

7. In (*apud*) Vergil we read about the taking of Troy.

Key to above Sentences.

1. Num tu mei similem putas esse aut tui deum? Profecto non putas. Quid ergo? Solem dicam aut lunam aut cœlum deum? Minime vero.

2. Cur non emptis (*abl. after* fruor), frueris? Quod (or quia), maximi (or maximo), emi.

3. Mihi persuasum est ut decem dies apud Ciceronem manerem.

4. Quid est durius saxo, quid mollius unda?

5. Eo audaciæ venerat ut imperatori parere nollet.

6. Semper in civitate, quibus opes nullæ sunt, bonis invident.

7. Apud Vergilium de capta Troja legimus.

Section III. TRANSLATION.

Put into English:

Si linguis hominum loquar et angelorum, caritatem autem non habeam, factus sum aes resonans aut cymbalum tinniens. Et si habeam prophetiam et noverim mysteria omnia, omnemque cognitionem, et si habeam totam fidem, adeo ut montes transferam, caritatem autem non habeam, nihil sum. Et si insumam *alendis egenis*[a] omnia quæ mihi suppetunt, et si tradam corpus meum ut comburar, caritatem autem non habeam, hoc nihil mihi *prodest*[b]. Caritas iram cohibet, benigna est caritas, non invidet caritas, non agit perperam, non inflatur: non agit indecore, non quærit quæ sua sunt, non exacerbatur, non cogitat malum. Non gaudet injustitia, gratulatur autem veritati; omnia tegit, omnia credit, omnia sperat, omnia sustinet: caritas nunquam excidit: sed et prophetiæ evanescent, et linguæ cessabunt, et cognitio evanescet. Ex parte enim cognoscimus, et ex parte prophetamus. Postquam autem advenerit quod perfectum est, tunc quod est aliquatenus, *ut*[c] inutile, tolletur. Quum essem infans, ut infans loquebar, ut infans sapiebam, ut infans ratiocinabar: postquam autem factus sum vir, ut inutilia *sustuli*[d] quæ infantis erant. Cernimus enim nunc per speculum et per ænigma, tunc autem coram cernemus: nunc novi aliquatenus, tunc vero amplius cognoscam, prout amplius edoctus fuero. Nunc vero manet fides, spes, caritas, tria hæc: maxima autem harum caritas.

NOTES. (*a*) dative of gerundive = for feeding the needy.

(*b*) from *prosum*, *prodesse*, *profui*.

(*c*) *Ut* with indic., or used without a verb, means "as."

(*d*) perfect of *tollo* (borrowed from *suffero*).

[For English of the above, see 1 Cor. xiii.]

Continued

ENGLISH

Continued from page 7[illegible]

By Gerald K. Hibbert, M.A.

VERBS—continued.

COMPLETE CONJUGATION OF THE VERB "TO SEE."

Active Voice.—Infinitive Mood.

Present Indefinite : (To) see
Present Incomplete : (To) be seeing
Perfect : (To) have seen
Continuous Perfect : (To) have been seeing

Participles.

Incomplete : Seeing. *Perfect :* Having seen
Continuous Perfect : Having been seeing

Indicative Mood.

PAST.	PRESENT.	FUTURE.
	Indefinite.	
I saw (*or*, did see)	I see (*or*, do see)	I shall see
	Incomplete.	
I was seeing	I am seeing	I shall be seeing
	Perfect.	
I had seen	I have seen	I shall have seen
	Continuous Perfect.	
I had been seeing	I have been seeing	I shall have been seeing

Imperative Mood.

Singular : See (thou). *Plural :* See (ye)

Subjunctive Mood.

PAST.	PRESENT.
Indefinite.	
I saw	I see
I should see	I may see
I might see	
Incomplete.	
I were seeing	I be seeing
I should be seeing	I may be seeing
I might be seeing	
Perfect.	
I had seen	I have seen
I should have seen	I may have seen
I might have seen	
Continuous Perfect.	
I had been seeing	I have been seeing
I should have been seeing	I may have been seeing
I might have been seeing	

Passive Voice.—Infinitive Mood.

Indefinite.	*Perfect.*
To be seen	To have been seen

Participles.

Indefinite : Being seen.
Perfect : Seen, *or* having been seen.

Indicative Mood.

PAST.	PRESENT.	FUTURE.
	Indefinite.	
I was seen	I am seen	I shall be seen
	Incomplete.	
I was being seen	I am being seen	I shall be being seen
	Perfect.	
I had been seen	I have been seen	I shall have been seen

(No Continuous Perfect in the Passive.)

Imperative Mood.

Singular : Be (thou) seen
Plural : Be (ye) seen

Subjunctive Mood.

PAST.	PRESENT.
Indefinite.	
I were seen	I be seen
I should be seen	I may be seen
I might be seen	
Incomplete.	
I were being seen	I be being seen
I should be being seen	I may be being seen
I might be being seen	
Perfect.	
I had been seen	I have been seen
I should have been seen	I may have been seen
I might have been seen	

The four simple tenses of the Active Voice are now given in full :

Indicative Mood.

PAST INDEFINITE.		PRESENT INDEFINITE.	
I saw	We saw	I see	We see
Thou sawest	You saw	Thou seest	You see
He saw	They saw	He sees	They see

Subjunctive Mood.

PAST INDEFINITE.	PRESENT INDEFINITE.	
(Same as Indicative.)	I see	We see
	Thou see	You see
	He see	They see

The Compound Tenses are conjugated exactly like the corresponding tenses of "be" and "have," except those tenses of the subjunctive containing *may, might,* and *should.* These will be dealt with below.

Impersonal Verbs. In such expressions as "it thunders," "it hails," "it behoves," "it seems," the subject is general and undefined. The *it* does not represent any definite noun as the subject. In "it thunders," for example, there is no particular *it* that is thundering : we simply mean "there is thunder somewhere." These verbs are therefore called *Impersonal,* there being no person expressed or understood as subject. They are always in the third person singular, though, of course, they can be of different tenses—*e.g., it thundered, it will hail.* While *it* is usually employed as the grammatical subject of such verbs, occasionally there is no subject expressed at all : as, *methinks* (= it seems to me), *meseems, maybe* ; also, *if you please,* which strictly means *if it please you, it* being subject and *you* object.

Auxiliary and Notional Verbs. If we compare the sentences "I have lost sixpence" and "I have sixpence," we see a great difference in the two uses of *have.* In the first sentence it has no meaning of its own, but simply "helps" to form the Present Perfect tense of "lose." In the second sentence, it has a meaning of its own, namely, "I possess." In the first case it is an *Auxiliary* (helping) Verb, in the second a *Notional* Verb (sometimes called *Principal*). The same applies to *shall, will, may, do, be—e.g.,* "I shall go to-morrow"

(*auxiliary*), and "You shall (*i.e.*, must) do it" (*notional*). "I will see you before long" (*auxiliary*), and "I will have my own way" (*notional*). "It may be wet to-morrow (*auxiliary*), and "You may (*i.e.*, are permitted to), go" (*notional*). "Do you think so?" (*auxiliary*), and "What will you do?" (*notional*). "I am coming (*auxiliary*), and "I *am* a man" (*notional*).

Defective Verbs. All the abovementioned verbs (except *have* and *be*), when used as auxiliaries, are "deficient" in certain tenses. They have no infinitive and no participles (*e.g.*, we cannot say "to shall" or "shalling"), and, therefore, have no compound tenses. Of course, when used as notional verbs, they are not necessarily defective. Thus, "to will" (meaning "to resolve") has all the compound tenses, "I have willed," etc.

1. DO.

Infinitive Mood.

Indefinite, (To) do; *Incomplete* (or *Imperfect*), (To) be doing; *Complete* (or *Perfect*), (To) have done.

Participles.

Imperfect, doing; *Perfect*, done; *Compound Perfect*, having done.

Indicative Mood.

Past Indefinite.		*Present Indefinite.*	
I did	We did	I do	We do
Thou didst	You did	Thou doest *or* dost	You do
He did	They did	He doeth *or* doth *or* does	They do

When used as a notional verb, *do* is conjugated in full; but when as an auxiliary, only the present and past indefinite are used (*do* and *did*). *Doest* and *doeth* are only used in the notional sense—*e.g.*, "*Doest* thou well to be angry?"

In such phrases as "That will *do*," "How does this *do*?" the *do* is quite a different verb, meaning "to suit, to avail" (from Anglo-Saxon *dugan*). We ought not to use *did* as the past tense of this *do*, though we are constantly using phrases like "I was anxious to see how it *did*."

2. WILL.

Indicative Mood.

Past Indefinite.

I would	We would
Thou wouldst	You would
He would	They would

Present Indefinite.

I will	We will
Thou wilt *or* willest*	You will
He will, willeth*, *or* wills*	They will

Subjunctive Mood.

Past Indefinite, I would, etc. (same as Past Indicative).

(No Present Tense.)

* The forms *willest*, *willeth*, and *wills* are not used when the verb is an auxiliary. When *will* means "to exercise the will," or "to bequeath by will," it has a full conjugation—*e.g.*, "This property *was willed* to me by my uncle," "It is not of him that *willeth*, nor of him that runneth," etc. (Romans).

The past indicative *would* is used as an auxiliary only in reported (or indirect) speech, to take the place of *will* in direct speech—*e.g.*, "He *will* come soon" (*direct*); "He said that he *would* come soon" (*indirect*).

Will is also used to express a customary or frequently repeated action—as: "He *will* play for hours," "When he was young, he *would* spend whole days in the fields and hedgerows."

Won't comes from *wol*, an old form of *will*.

When *will* is an auxiliary verb, it has no infinitive, no imperative, and no participles (consequently, no compound tenses).

3. SHALL.

Indicative Mood.

Past Indefinite.

I should	We should
Thou shouldst	You should
He should	They should

Present Indefinite.

I shall	We shall
Thou shalt	You shall
He shall	They shall

Subjunctive Mood.

Past Indefinite.

I should	We should
Thou shouldest *or* shouldst	You should
He should	*They should*

Present Indefinite.

(None.)

No Infinitive, Imperative, or Participles, whether used as auxiliary or as notional verb.

The past indicative *should* is used as an auxiliary only in reported speech, representing *shall* in direct speech.

Shall comes from Anglo-Saxon *sculan* = to owe, and hence arose the meaning of obligation—as: "He *shall* do it," "You *should* answer when your mother speaks." When *shall* retains this idea of "obligation" it is a notional verb; used as an auxiliary, it loses this force.

Both *shall* and *will* are followed by the infinitive without *to*—as: "He *will* not *come*."

4. MAY.

Indicative Mood.

Past Indefinite.

I might	We might
Thou mightest	You might
He might	They might

Present Indefinite.

I may	We may
Thou mayest *or* mayst	You may
He may	They may

Subjunctive Mood.

(Same as Indicative.)

Might gets the *g* from the Anglo-Saxon form of *may*, which was *maeg* (German, *mögen*).

May has no infinitive, imperative, or participles; and in its indicative mood it is never

auxiliary, but always notional—*e.g.*, "You may go" (*i.e.* "You are permitted to go"). "The fish might be seen rising at any hour almost" (*i.e.*, it was possible to see them). In the subjunctive mood, of course, it can be an auxiliary—*e.g.*, "We eat in order that we may live," "May it be so," "I am come that they might have life."

[There is a totally distinct verb "to may," meaning "to gather may-blossom." This verb is fully conjugated in the active voice, as "O that we two were maying." Being intransitive, it has no passive.]

We have now discussed all the auxiliary verbs, namely, *be*, *have*, *do*, *will*, *shall*, and *may*. The following three verbs, *can*, *must*, and *ought*, are sometimes called auxiliaries: but they do not help to form any tense, mood, or voice of any verb.

5. CAN.

Indicative Mood.

Past Indefinite.

I could	We could
Thou couldest *or* couldst	You could
He could	They could

Present Indefinite.

I can	We can
Thou canst	You can
He can	They can

Subjunctive Mood.

Past Indefinite.	*Present Indefinite.*
(Same as Indicative.)	(None.)

No Infinitive, Imperative, or Participles.

Can is from an old verb *cunnan*, meaning "to know" (German, *können*). "I can read" therefore really means "I know how to read"—*e.g.*, *Lycidas*, "He knew to sing." We have this meaning still preserved in "to con," and in the Scotch "to ken." "Cunning" is the old imperfect participle of this verb, and *couth* the past participle (*cf.* *uncouth*, which means *unknown* and therefore *strange*).

As *can* originally meant "to know," it required no infinitive—*cf.* *Hamlet*, "They *can* well on horseback"; *Lay of the Last Minstrel*, "Other prayer *can* I none." Bacon even has "not to *can*."

The *l* of *could* does not belong to the verb; it was inserted owing to a false analogy with *should* and *would*. It should strictly be spelt *coud*.

Can is always a notional or principal verb—*e.g.*, "I *can* write" (*i.e.*, "I am able to write"); "I would if I *could*" (*i.e.*, "I would if I were able"). To call such sentences examples of the "Potential Mood" is absurd; in the first sentence *can* is a simple indicative, and in the second, *could* is a simple subjunctive.

[*To can*, meaning "to put into a can," is, of course, quite regular.]

6. MUST.

Like *can*, this is always a notional verb. It has no inflexions for tense or person, all the persons of each number of each of the two indicative tenses being alike *must*. It has no subjunctive, infinitive, imperative, or participles.

The old form of the present indicative was: I *mot*, Thou *most*, He *mot*, which shows that the *s* does not strictly belong to the first and third persons singular.

The past indicative *must* is used only in reported speech—*e.g.*, "I *must* go" (direct speech, present tense), "He said that he *must* go" (indirect, past tense, meaning "that he *was* obliged to go").

7. OUGHT.

Ought is the past indefinite tense of *owe*. Thus, in Shakespeare's "King Henry IV." the hostess says, "He said this other day you *ought* (= owed) him a thousand pounds." It is now used as a present, in the sense of moral obligation, as "I *ought* to be a better man."

With both *must* and *ought*, to express a past tense the verb following requires to be in the perfect infinitive, as "I *ought* to *have done* it at the time," "You *must have enjoyed* your trip."

Owe originally meant *to own*, *to possess*, as "This is no mortal business, nor no sound that the earth *owes*" ("Tempest"); "I am not worthy of the wealth I *owe*" ("All's Well"), and the modern adjective *own* is the past participle of this verb ("Give me back my *own* money" means "Give me back the money you possess for me").

Owe, "to be in debt," is quite regular: *I owed*, *I shall owe*, etc.

8. DARE (*to venture*).

The third person singular of the present indicative is properly "he dare," *not* "he dares." The reason is that "I dare" is an old *past* tense, and is not really a present at all—*e.g.*, "Mine unworthiness, that *dare* not offer, etc." ("Tempest"). We now use "I durst" as the past tense of *dare*, followed by the infinitive without *to*, as "He durst not do it." When *dare* is a transitive verb meaning "to challenge," it is perfectly regular (past tense *dared*, as "She dared him to come on").

9. NEED

When *to need* means "to lack, to be in want of," it is perfectly regular. But when it means "to be under the necessity of doing a thing," the third person singular present indicative is often "he *need*," not "he *needs*," as, "He need not go just yet." Contrast this with "He *needs* brains"—*i.e.*, "he lacks brains." Note that *needs* in sentences like "Such things must needs be" is an adverb. In the Authorised Version of the Bible the usual form of the third person singular present indicative is *needeth*.

10. WIT (*to know*).

Indicative Mood.

Past Indefinite.

I wist	We wist
Thou wist	You wist
He wist	They wist

Present Indefinite.

I wot	We wot
Thou wottest *or* wost	You wot
He wotteth *or* wot	They wot

Present Infinitive—To wit.

Present Participle—Witting *or* wotting (*cf.* *unwitting*, Milton *unweeting*).

Examples:

"'Twas I did the thing you wot of" ("Two Gentlemen of Verona").

"My master wotteth not what is with me in the house" (Genesis).

"He that was healed *wist* not who it was" (St. John).

This verb is hardly ever used now, except the infinitive *to wit* in the sense of "namely," "that is to say," representing the Anglo-Saxon gerund *to witanne*.

11. QUOTH.

Quoth is the past tense of *cwethan* (= *to say*—note the infinitive termination *an*). It is used only in this tense, and only in the first and third persons singular. It always comes before its subject, as *quoth he*, and is used parenthetically for "said I," "said he." Examples: "*Quoth* the raven, 'Nevermore'," "'To tame your fierce temper,' *quoth* she" (Browning).

12. ME-THINKS.

This is not "I think," but "it seems to me," the *me* being dative or indirect object, and *thinks* being third person singular present indicative of *thyncan* = *to seem*. The only forms in use are *me-thinks* and *me-thought*. Milton has the form *him thought*—"Him thought, he by the brook of Cherith stood." In "Richard III.," Act iii. Scene 1, some read "Where it *thinks* best unto your royal self."

13. LISTS.

In *me-lists* = *it pleases me*, and *him-listed*, lists is an impersonal verb (*cf.* "when and where *likes* [pleases] me best"—"Paradise Regained"). *List* is also used personally, as "The wind bloweth where it *listeth*," "Whithersoever the *governor listeth*."

14. WORTH.

This verb is used only in the third singular present subjunctive, expressing a wish, as, "Woe *worth* the day" = "May woe befall the day" (*day* being indirect object or dative). It is from the old verb *weorthan* = to become (German, *werden*).

15. HIGHT.

Hight means "was called," "was named." It is from an old verb *hatan*, "to be named" (German, *heissen*)—*e.g.*, "That shallow vassal . . . *hight* Costard" ("Love's Labour Lost").

16. DIGHT.

This is past participle of *dihtan* = to deck, to adorn—*e.g.*:

"With their small feet purple-sandal'd
And their arms with bracelets *dight*."

"Who checks at me, to death is *dight*."
(Marmion.)

EXERCISE.

Explain every *should* and *would* in the following:

She would often say "Would I were a man! I *should* have been, for then I would have shown the world a lesson it would never forget." I would reply that I should not attempt to argue with her lest she should get angry; but I now often think that I should have done so. For perhaps I should have convinced her that it would not have been so easy. Should I, or should I not, I wonder?

Continued

FRENCH

Continued from page 752

By Louis A. Barbé, B.A.

THE NOUN.

Gender.

1. In French there are only two genders, masculine and feminine (*le masculin, le féminin.*) The rules for ascertaining the gender of nouns are based on their meaning or on their ending.

GENDER ACCORDING TO MEANING.

1. MASCULINE.

(*a*) Nouns indicating males are masculine: *le soldat*, the soldier; *le marin*, the sailor; *le capitaine*, the captain; *le laboureur*, the husbandman.

Exceptions are: *une connaissance*, an acquaintance; *une dupe*, a dupe; *une personne*, a person; *une victime*, a victim; and some military terms, such as: *une sentinelle*, a sentry; *une recrue*, a recruit, which are feminine.

(*b*) The names of the days of the week, of the months, and of the seasons are masculine. They are:

dimanche, Sunday.	*mercredi*, Wednesday.
lundi, Monday.	*jeudi*, Thursday.
mardi, Tuesday.	*vendredi*, Friday.
samedi, Saturday.	

janvier, January.	*juillet*, July.
février, February.	*août*, August.
mars, March.	*septembre*, September.
avril, April.	*octobre*, October.
mai, May.	*novembre*, November.
juin, June.	*décembre*, December.
printemps, spring.	*automne*, autumn.
été, summer.	*hiver*, winter.

The mid-month is formed by prefixing *mi-*, and in that case the noun becomes feminine: *la mi-janvier, la mi-août*.

(*c*) The names of trees and shrubs are masculine: *le chêne*, the oak; *le hêtre*, the beech; *le pommier*, the apple-tree; *le rosier*, the rose-bush.

Exceptions are: *une aubépine*, a hawthorn; *la bruyère*, heather; *la bourdaine*, the black alder; *une hièble*, a dwarf elder; *la ronce*, the briar; *la vigne*, the vine; *une yeuse*, an evergreen oak, all of which are feminine.

(*d*) The names of metals, minerals, gases, and chemical substances are masculine: *le fer*, iron; *le mercure*, mercury; *l'oxygène*, oxygen; *le nitrate*, nitrate; *l'étain*, zinc; *le manganèse*, manganese; *le jais*, jet.

Exceptions are: *l'argile*, clay; *l'agate*, agate; *la craie*, chalk; *la houille*, sea-coal; *la chaux*, lime.

(*e*) The names of colours are masculine: *le rouge*, red; *le bleu*, blue; *le blanc*, white.

An exception is *la sépia*, sepia—*e.g.*, *un dessin à la sépia*, a sepia drawing.

(*f*) Names of languages are masculine: *le français*, French; *l'anglais*, English.

(*g*) Names of weights and measures (in the decimal system) are masculine: *le mètre*, *le litre*.

Exceptions: Some of the old names that are occasionally used, particularly for the literal translation of English weights and measures, are feminine:

une aune, an ell.	*une livre*, a pound.
une brasse, a fathom.	*une once*, an ounce.
une coudée, a cubit.	*une pinte*, a pint.
une lieue, a league.	*une quarte*, a quart.

(*h*) The points of the compass are masculine:

le nord, north.	*l'est*, east.
le sud, south.	*l'ouest*, west.

(*i*) The names of mountains are masculine, except in some plural forms, as: *les Alpes*, *les Pyrénées*, *les Vosges*, *les Cévennes*, which are feminine.

(*j*) All words belonging to other parts of speech are masculine when used as nouns: *le sublime*, *un sixième* (one-sixth), *le manger et le boire* (eating and drinking), *les mais et les si* (but's and if's).

2. Feminine.

(*a*) Nouns indicating females are feminine: *la mère*, the mother; *la sœur*, the sister.

Exceptions: The following nouns remain masculine even when applied to women:

un amateur, a lover or fancier (of animals, art, etc.).	*un peintre*, a painter. *un philosophe*, a philosopher.
un ange, an angel.	*un possesseur*, a possessor.
un artisan, an artisan.	*un poète*, a poet.
un auteur, an author.	*un professeur*, a professor.
un censeur, a censor.	*un sauveur*, a saviour.
un chef, a chief.	*le successeur*, the successor.
le défenseur, the defender.	*le témoin*, the witness.
un docteur, a doctor.	*un traducteur*, a translator.
l'écrivain, the writer.	*un tyran*, a tyrant.
l'imposteur, the impostor.	
un partisan, a partisan.	

(*b*) Abstract nouns, the names of arts, science, professions, virtues, and vices, are feminine:

la sagesse, wisdom.	*la chimie*, chemistry.
la peinture, painting.	*la charité*, charity.
la poésie, poetry.	*l'avarice*, avarice.

The following, all of which are masculine, are exceptions to this rule:

le courage, courage.	*l'orgueil*, pride.
le dessin, drawing.	*le péché*, sin.
le jeu, gambling.	*le plaisir*, pleasure.
le mensonge, lying.	*le vice*, vice.
le mérite, merit.	*le zèle*, zeal.

Note. The gender of most words included in both the rule and the exceptions can also be determined by their endings.

(*c*) The names of diseases and ailments are feminine: *la toux*, cough; *la fièvre*, fever; *la rougeole*, measles; *la petite vérole*, small-pox; *une migraine*, headache; *la coqueluche*, whooping-cough; *la grippe*, influenza; *la goutte*, gout.

Exceptions are: *le choléra*, cholera; *un rhume*, a cold; *le rhumatisme*, rheumatism; *le typhus*, typhus.

(*d*) The names of fruits are feminine: *la pomme*, the apple; *la cerise*, the cherry; *la prune*, the plum; *la poire*, the pear.

Exceptions are: *un ananas*, a pineapple; *le brugnon*, the nectarine; *un abricot*, an apricot; *un coing*, a quince; *un citron*, a lemon; *des cassis*, black-currants; *un raisin*, a grape, all these being masculine.

(*e*) The names of festivals and saints' days are feminine, even when the saint's name is masculine: *La Toussaint*, All Saints' Day; *La Saint-Michel*, Michaelmas.

An exception is *le Noël*, Christmas.

Gender according to Termination.

1. Masculine.

(*a*) Nouns ending in *b*, *c*, *d*, *g*, *l*, *p*, *q*, or *z* are all masculine:

le plomb, lead.	*le baril*, the barrel.
le bac, the ferry.	*le coup*, the blow.
le bord, the edge.	*le coq*, the cock.
le rang, the rank.	*le nez*, the nose.

(*b*) F is a masculine ending, except in *la clef*, the key; *la nef*, the nave; *la soif*, thirst.

(*c*) M is a masculine ending, except in *la faim*, hunger, and the place name *Jérusalem*.

(*d*) N is a masculine ending except in *la fin*, the end; *la main*, the hand.

(*e*) R is a masculine ending, except in *la chair*, flesh; *la cour*, court, courtyard; *la cuiller*, spoon; *la mer*, sea; *la tour*, the tower.

(*f*) S is a masculine ending, except in *la brebis*, sheep (ewe); *la fois*, time (as in *une fois*, once = one time); *la souris*, mouse; *la vis*, screw.

(*g*) T is a masculine ending, except in *la dent*, tooth; *la dot*, dowry; *la forêt*, forest; *la gent*, race; *la hart*, halter; *la nuit*, night; *la part*, share. *Jument*, mare, is the only word ending in *ment* that is feminine.

(*h*) X is a masculine termination, except in *la chaux*, lime; *la croix*, cross; *la faux*, scythe; *la noix*, walnut; *la paix*, peace; *la perdrix*, partridge; *la poix*, pitch; *la toux*, cough.

(*i*) A is a masculine ending, except in some names of dances, as *la polka*, polka.

(*j*) É (not preceded by *t*) is a masculine ending, as *le thé*, *le café*.

(*k*) I is a masculine ending, except in *la fourmi*, ant; *la merci*, mercy; *une après-midi*, afternoon.

(*l*) O, which only occurs as final in *l'écho*, echo, is a masculine ending.

(*m*) U and *ou* are masculine endings, except in *la bru*, daughter-in-law; *la glu*, birdlime; *la tribu*, tribe; *la vertu*, virtue.

(*n*) *Eau* is a masculine ending, except in two words, *l'eau*, water; *la peau*, skin.

(*o*) *Oi* is a masculine ending, except in *la foi*, faith; *la loi*, law; *la paroi*, partition wall.

(*p*) **Nouns ending in *acle* and *ocle* are masculine, except *la débâcle*, breaking-up of the ice, and, figuratively, downfall.**

(*q*) Nouns ending in *age*, *ège* and *ige* are masculine, except *la cage*, cage; *la nage*, swimming; *la plage*, shore; *la rage*, rage and rabies; *la page*, page (of a book); *une image*, image; *une allège*, a lighter; *la tige*, stalk.

(*r*) Nouns in *aume* are masculine, except *la paume*, palm (of the hand), tennis.

(*s*) Nouns in *aire* are masculine, except *une affaire*, affair; *la circulaire*, circular; *la chaire*, pulpit; *la paire*, pair; *aire*, area.

(*t*) Nouns in *asme* and *isme* are all masculine.

(*u*) Nouns in *âtre*, *itre*, *iste* and *ogue* are masculine, except *la marâtre*, stepmother; *une huitre*, oyster; *la vitre*, window-pane; *la piste*, track; *la vogue*, vogue; *une églogue*, eclogue.

2. Feminine.

(*a*) Nouns ending in mute *e* preceded by *é* are feminine, except a few proper names, such as *Amédée*, *Persée*, and words in which *ée* represents *eum*, as *la musée*, museum; *la Colisée*, Colosseum.

(*b*) Nouns ending in mute *e* preceded by *i* or *u* are feminine, except *le génie*, genius; *un incendie*, fire; *le parapluie*, umbrella.

(*c*) Nouns ending in mute *e* preceded by a double consonant are mostly feminine. The chief exceptions are *le beurre*, butter; *le lierre*, ivy; *le parterre*, flower-bed, also pit (in a theatre); *le tonnerre*, thunder.

(*d*) Nouns in *ade* and *ude* are feminine, except *le grade*, grade, degree; *le camarade*, comrade; *un interlude*, *le prélude*.

(*e*) Nouns in *ure* are feminine, except *un augure*, augury; *le murmure*, murmur; *le parjure*, perjury and perjurer; and words belonging to the terminology of chemistry, as *le cyanure*, cyanide.

(*f*) All nouns in *aille* and *ouille* are feminine.

(*g*) All nouns in *ette* are feminine, except *le squelette*, skeleton.

(*h*) All nouns in *ance*, *ense*, and *ence* are feminine, except *le silence*.

(*i*) Nouns in *té* are feminine, except *le côté*, side; *le comité*, committee; *le comté*, county; *été*, summer; *en pâté*, a pasty; *un traité*, a treaty, also treatise; and a few more not of frequent use.

(*j*) All nouns in *tion* are feminine, with the one exception of *le bastion*, bastion.

(*k*) Nouns in *aison* are feminine.

(*l*) All abstract nouns in *eur* are feminine, except *l'honneur*, honour; *le labeur*, toil; *le bonheur*, happiness; *le malheur*, misfortune.

Double Gender.

Some words that are spelt alike differ in meaning according as they are masculine or feminine. Of such words the following occur frequently:

le crêpe, crape.	*le mode*, mood.
la crêpe, pancake.	*la mode*, fashion.
le livre, book.	*le mousse*, ship-boy.
la livre, pound.	*la mousse*, moss.
le manche, handle.	*le page*, page (boy).
la manche, sleeve,	*la page*, page (of a book).
le mémoire, memorandum.	*le pendule*, pendulum.
la mémoire, memory.	*la pendule*, timepiece.
le poêle, stove, pall.	*la tour*, tower.
la poêle, frying-pan.	*le vase*, vase.
le poste, post, station.	*la vase*, ooze, mud.
la poste, post-office.	*le vapeur*, steamboat.
le somme, nap.	*la vapeur*, steam.
la somme, sum.	*le voile*, veil.
le tour, turn, trick, tour.	*la voile*, sail.

Exercise V.

Vocabulary.

année (f.), year. (*a-ney*)
arbre (m.), tree. (*ar-br*)
arbrisseau (m.), shrub. (*ar-brees-so*)
fleur (f.), flower. (*flĕr*)
fruit (m.), fruit. (*frü-ee*)
leçon (f.), lesson. (*leh-song*)
mois (m.), month. (*mwah*)
neige (f.), snow. (*nayj*)
saison (f.), season. (*say-zong*)
derrière, behind. (*der-ree-err*)
premier (m.), first. (*prĕ-mee-ey*)
première (f), first. (*prĕ-mee-err*)
quatre, four. (*kăhtr*)

1. There are four seasons: [the] spring, [the] summer, [the] autumn, and [the] winter. 2. Spring is the first season of the year. 3. Winter is not the season of [the] flowers. 4. In (*en*) summer there is no snow. 5. The month of December is one of the months of winter. 6. The apple is the fruit of the apple-tree. 7. The briar has no fruit. 8. The oak is a tree, [the] heather is a shrub. 9. There are a beech and a hawthorn behind the house. 10. He has a plum, she has an apricot, and we have some cherries. 11. There is a bird in the cage. 12. The children are on the shore. 13. The brother and sister have the measles. 14. I have a headache. 15. Lying is a vice. 16. The sentry is not a recruit. 17. There is a picture on the first page of the book. 18. I write with chalk. 19. The sailor and the cabin-boy love (*aiment*) the sea. 20. The end of the lesson.

KEY TO EXERCISE IV.

1. Le papier du livre. 2. Le héros de l'histoire. 3. Le haut de la maison. 4. Le crayon de l'enfant. 5. Voilà la plume. 6. Voilà la règle. 7. L'encre est dans l'encrier. 8. L'encrier est sur la table. 9. Il y a un encrier sur la table. 10. La hauteur de la maison. 11. Il y a un livre, un encrier, un buvard, une règle et un cahier sur la table. 12. De la chaise à la table. 13. Le père et la mère sont dans la maison. 14. La charité est une vertu. 15. Le fer est un métal. 16. L'homme a un frère et une sœur. 17. Les enfants ont des grammaires. 18. Voilà le livre d'un des enfants. 19. J'ai parlé aux enfants de la femme. 20. J'écris au frère et à la sœur. 21. J'ai des crayons. 22. Elle n'a pas d'encre. 23. Vous avez besoin de plumes et de papier. 24. Il a de bons livres. 25. Vous avez des crayons et du papier; nous n'en avons pas. 26. Vous avez de bonnes plumes. 27. Le père de l'enfant a une maison. 28. Voilà le père de l'enfant. 29. Elle a besoin d'encre et de papier. 30. L'or et l'argent sont utiles aux hommes. 31. Les enfants n'ont pas de patience. 32. La patience est une vertu.

Continued

Group 23 NATURAL HISTORY 6

Continued from page 732

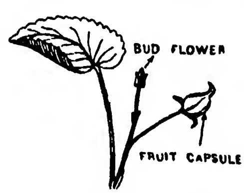
HOW FLOWERS COVER THE EARTH

Natural Agents Engaged in Dispersing Seeds. Action of Water and Wind. The Part Played by Insects, Birds and Animals

By Professor J. R. AINSWORTH DAVIS

Bees and Butterflies as Guests. We may give the name "Bee-Butterfly Flowers" to such as primrose (*Primula vulgaris*) and dog-violet (*Viola canina*), which are visited chiefly by bees and butterflies. The former is of great interest, because it possesses two kinds of blossom [**104**]. In one ("thrum-eyed"), the five anthers occupy the mouth of the corolla tube, and the rounded stigma is borne upon a shorter style. In the other kind ("pin-eyed"), the anthers are deep down in the tube, while the stigma is on a long style and occupies its entrance. It naturally follows that the pollen from one kind of flower is likely to be transferred to the stigma of the other. This sort of arrangement is carried still further in purple loosestrife (*Lythrum Salicaria*), where the flowers are of three different kinds—*i.e.*, with long style, medium stamens and short stamens; with long stamens, medium style, and short stamens; and with long stamens, medium stamens, and short style. The best seeds are produced when a flower with style of given length is crossed by pollen from another stamen of corresponding length.

In dog-violet (*Viola canina*) [**119**, p. 730] the irregular purple flower presents an alighting platform, and well-marked streaks, together with an orange-coloured patch, serve as nectar-guides, marking the entrance to the spur in which nectar is stored. The curious hood-shaped stigma is placed at the entrance of the blossom, and the five anthers surround the style, shedding their dusty pollen into the space so enclosed. An insect visitor is pretty certain to get dusted with this pollen, and to transfer some of it to the stigma of the next flower visited.



129. DOG-VIOLET

The Fly's Visit to the Speedwell. Among the higher two-winged insects known as flies there are some called "hover-flies," on account of the peculiar way in which they remain suspended, as it were—*i.e.*, hover—at a particular spot, and then dart away rapidly in a sidelong fashion. The germander speedwell (*Veronica chamædrys*) [**128**, page 730] is one of our native flowers adapted to the visits of guests of this kind. It is of a beautiful blue colour, and slightly irregular, with only two stamens instead of the five possessed by its relative the mullein, or the four to be found in the allied foxglove and snapdragon. The last two have lost the top stamen, to allow of the style with its stigma pressing up against the upper side of the corolla; but speedwells have lost two more, so as to fit them for the kind of visit to be now described.

The flower is flat when expanded, and dark-blue lines converge to the white centre of the corolla, indicating very clearly where the nectar is to be found. The long style with its stigma projects obliquely forwards and downwards, and the two long stamens project outwards and somewhat sideways. The insect guest first hovers in front of the flower, apparently delighted with its bright hue, and then darts forward to suck the nectar, seizing the two filaments as it does so, and drawing them under its body to serve as a support. Being very attenuated at their bases they are easily moved. The two anthers are thus brought into contact with the body of the insect, and dust it with pollen, some of which is almost certainly transferred to the stigma of the next flower visited.

Flowers with Fly Traps. A number of flowers possess traps by which small flies are caught and held prisoner until they have done the work required of them. Our common wild arum (*Arum maculatum*) [**111**], or cuckoo-pint, presents us with a striking arrangement of the kind. The flowers are enclosed in a chamber formed by the lower part of a large green bract (*spathe*), which opens to display a thickened purple stem (*spadix*), upon the base of which these flowers are arranged in two crowded sets, of which the lower ones are female and the upper ones male.

Above the last are a number of downwardly directed trap-hairs, which are no other than modified male flowers which have lost their original function. Small flies are attracted by the dull purple colour of the spadix and by an ammoniacal odour which is exhaled. Creeping down the spadix or inner side of the spathe they easily make their way past the trap-hairs, and find themselves prisoners in the chamber containing the flowers. At this time the stigmas are mature, and should any arum pollen be sticking to the bodies of the little visitors they are likely to receive some of it.

When this takes place the stigmas wither, and each of them exudes a drop of nectar as payment for services rendered. The stamens next shed their pollen, and some of this is likely to stick to the guests, who are at last allowed to escape, since the trap-hairs wither [**112**]. The pollen is carried by them to another arum in a certain proportion of cases.

The Disappointed Foxglove. In many of the less specialised flowers the chances of cross and self-pollination are about equal, while some of the more inconspicuous forms rely very largely upon the latter, as, for example, chickweed (*Stellarix media*), and the smaller kinds of wild geranium. And a very large proportion even of irregular specialised flowers are self-pollinated as a sort of last resort. A good instance of this is afforded by the foxglove (*Digitalis purpurea*), for in the last stage of flowering, should humble-bees have failed to visit it, the purple corolla falls off and drags the pollen-covered anthers over the stigma.

In the daisy and dandelion order (*Compositæ*) there is a pretty arrangement which may be illustrated by sunflower (*Helianthus annuus*). Here the central disk-florets pass through the following stages [106, read from left to right]. The anthers are united into a hollow cylinder, into which the pollen is shed. From this it is pushed out by the two stigmas, which are provided with sweeping hairs for the purpose, but, being pressed close together, are not self-pollinated. This pollen is more or less carried off by insects. The stigmas now diverge, laying themselves out to receive pollen from another flower. Failing this, they curl back, and are self-pollinated by some of the grains which reman clinging to the sweeping hairs.

There are some species which go still further, for in addition to the ordinary flowers they produce small bud-like ones, which never open, and fertilise themselves with their own pollen. Such flowers are easily to be seen on the dog-violet (*Viola canina*) [129] towards the end of summer, at the time when the fruits produced by the ordinary conspicuous flowers are ripe. The wood sorrel (*Oxalis acetosella*) is another example of the same kind.

130. STORKSBILL (Erodium)

131. BALSAM (Impatiens)

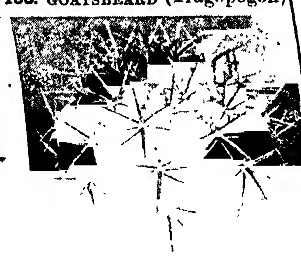
Abies Pterospermum Pinus

132. WINGED SEEDS

Top view Side view

133. GOATSBEARD (Tragopogon)

134. CLEMATIS



135. ECHINOCACTUS

Photographed by Prof. B. H. Bentley

DISPERSAL OF SEED-PLANTS

We have now considered in some detail the means by which the continuance of the species is effected. But as plants are not able to move about actively, it is necessary that there should be some provision for dispersal of their offspring, so that some at least of them may be able to find a suitable spot where they can grow up. Certain species actively disperse themselves, while others are scattered by water, wind, or animals.

How the Plants form Colonies. There are many plants which send off more or less horizontal branches below or above the ground, from the nodes of which roots grow down and shoots grow up, so that a sort of colony is produced, with members which may be arranged in a row or in a cluster. The cases of the sand sedge (*Carex arenaria*) and strawberry (*Fragaria vesca*) have been spoken of elsewhere. Other familiar examples with underground stems are mint (*Mentha*), millefoil (*Achillea millefolium*), reed (*Phragmites communis*), couch-grass (*Agropyrum repens*), stinging nettle (*Urtica dioica*), butterbur (*Petasites officinalis*), and coltsfoot (*Tussilago Farfara*). The last four are well-known weeds which it is very difficult to eradicate, owing to the way in which their numerous underground stems tunnel through the ground.

A variation on the arrangement just described is seen in tuberous plants such as the potato (*Solanum tuberosum*), where underground branches swell up into tubers from the "eyes" or buds of which new plants arise. If forms such as these are left to themselves, clustered colonies will soon be produced.

The dark-green rings in pastures with which we are familiar in this country are mostly formed by toadstools, which spread outwards from a centre, exhausting the ground as they do so.

There are, however, some seed-plants in which the same habit is observable, the ring being due to the death of older members of the colony which once occupied the middle of the patch. The Swedish fairies are popularly supposed to be especially fond of holding their midnight revels within the rings formed by a kind of grass (*Sesleria cærulea*).

Plants which Sow their Own Seeds. There is a kind of clover (*Trifolium subterraneum*) in which the pods produced on the lower part of the plant bend down towards the ground, into which they are forced by the growth of the branches that bear them. While in a kind of vetch (*Vicia amphicarpa*), native to South Europe, some of the flowers are self-fertilised and borne on underground shoots.

Some detached fruits bury themselves in the ground. That of storksbill (*Erodium*), for instance, possesses a spirally twisted awn, which uncoils when moist, and pushes the fruit into the earth [130].

The fruits of a number of plants are in a state of tension when ripe, and finally open or split suddenly in such a way as to eject the seeds to a considerable distance. One of the commonest examples is afforded by broom (*Sarothamnus scoparius*), the flat, black pods of which may often be heard exploding in late summer, the two halves curling up so that the seeds are scattered in all directions [136]. A similar case is that of balsam (*Impatiens noli-me-tangere*), the ripe capsules of which split into four twisting strips at the least touch, with the same result [131]. The seeds of wood sorrel (*Oxalis acetosella*) suddenly fly out from the mature capsule, owing to the rapid swelling up of a layer of the seed-coat, which is in a state of compression. The squirting cucumber (*Ecballium elaterium*) of South Europe presents us with a different kind of mechanism, for when ripe, it is, so to speak, over-full of fluid, and, as a result, the stalk is suddenly forced off and the seeds squirted out [137].

How Seeds Spread Over the Earth. *Sling fruits* resemble some of the preceding in certain respects, but owe their name to the way in which the seeds are propelled. In the marsh cranesbill or geranium (*Geranium palustre*), for example, each of the five compartments of the fruit is continued into an elastic fibre running up the beak like a prolongation, which has suggested the popular name. The compartments with their fibres ultimately curl up suddenly, owing to the elasticity of the latter, and the seeds are flung for a considerable distance [138].

In many *catapult fruits*, the ripe seeds, or, it may be, parts of the fruit, are contained in an open cup, and get thrown out by the quick recoil of the very elastic stems and flower-stalks when these are moved by the wind or brushed against by animals. In wood-sage (*Teucrium*) and other members of the dead-nettle order (*Labiatæ*) this cup is the calyx, in which the little separate divisions (nutlets) of the fruit are contained [139]; while in various species of the poppy [140], lily, iris, pink, primrose, or foxglove kind the dry fruit splits or opens to form a cup or hole-pierced capsule, and it is the seeds which are shot out.

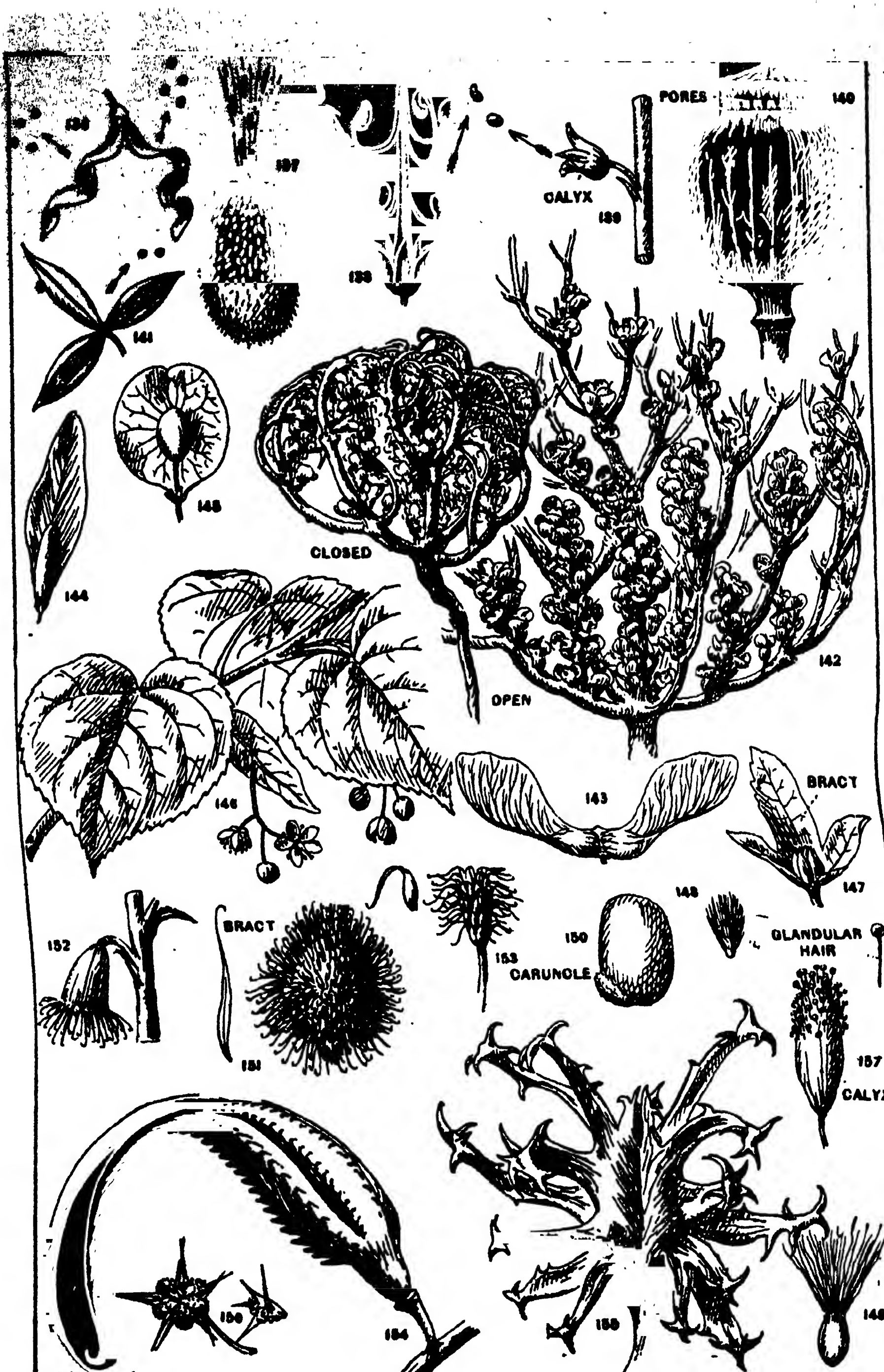
Flipping fruits include cases where the fruits are exceedingly smooth, and are pinched by contracting parts of the open fruit so as to be flipped to some distance, just as orange-pips can be shot from between the thumb and forefinger. An easily-observed instance is that of dog-violet (*Viola canina*), where the capsule splits into three parts, within each of which are two rows of shining seeds [141].

The Coco-nut Palm's Sea Voyage. The dispersal of plants by water is the method naturally adopted in the case of some of the plants which live and ripen their fruits in running water, but the method is not limited to them alone, for it may occur in some land forms. A notable case is that of the coco-nut palm, the fruits of which are invested in a thick fibrous husk, entangling hair, and covered with a tough skin. They may be carried for thousands of miles by ocean currents without getting water-logged or losing their power of germination, and it naturally follows that this palm is one of the commonest forms of vegetation in the coral islands of the Pacific.

The name *roses of Jericho* was applied in the Middle Ages to two plants native to the steppes of south-east Asia and North Africa. One of them (*Anastatica hierochuntica*) [142] belongs to the wallflower order (*Cruciferæ*), and, when its fruits are ripening during the dry season, the branches curl over them so as to give a remote resemblance to a rose that has not yet opened. When the rainy season sets in, the branches spread out, the fruits open, and the seeds are washed out.

Plants Dispersed by the Wind. Some of the plants native to the steppes of Russia and South-west Asia form a rounded branching mass, which is easily detached from the root at the time when the fruits are maturing, and gets rolled like a ball along the ground by the wind. A good example is a species of plantain (*Plantago cretica*), and there are a good many others. As great numbers of such plants often stick together to make up a very large and increasing mass, which may at times be caught up into the air, they have become objects of superstition, and have given rise to legends of wind or steppe witches. Other species growing in similar localities produce round and very light fruits, which are easily blown along the surface of the ground for great distances.

There are some plants which produce innumerable flattened seeds of such small size that they can be blown about like grains of dust. Orchids afford the best example, and it is easy to see how the tropical members of the group get dispersed among the branches of the trees where they mostly grow. For an extreme case, it has been calculated that over 30,000 seeds only weigh 1 grain (437½ grains = 1 oz. avoirdupois).



36. Broom. 137. Squirting cucumber. 138. Geranium palustre. 139. Teucrium. 140. Poppy. 141. Dog-iolet. 142. Rose of Jericho. 143. Sycamore. 144. Ash. 145. Elm. 146. Lime. 147. Hornbeam. 148. illow. 149. Willow herb. 150. Pansy. 151. Burdock. 152. Agrimony. 153. Avens. 154. Martynia. 155. Harpagophyton. 156. Tribulus. 157. Plumbago

In a large number of trees, tall shrubs, and herbs, the fruits or seeds are provided with membranous expansions which are easily caught by the wind. The "keys" of maple, sycamore [143], ash [144], and elm [145] are common examples of winged fruits, while in hop, lime [146], and hornbeam [147] a bract serves as a sail.

The Scotch pine (*Pinus sylvestris*) and Abies will serve as good examples of winged seeds [132].

In many members of the dandelion order (*Compositæ*) the calyx is transformed into a beautiful crown of hairs ("pappus"), which serves as a parachute. The dandelion itself (*Taraxacum officinale*) is a particularly instructive example. While the head of crowded yellow florets is maturing the stalk is short and near the ground, but it elongates and stands erect when the florets open to attract insects. Pollination and fertilisation accomplished, the stalk moves down so that the fruits can ripen in comparative safety close to the earth. When they are ripe the stalk once more becomes vertical, the crowns of hair spread out, and the fruits of the "dandelion clock" are blown hither and thither by every wind that blows. Equally familiar and of the same nature is "thistledown," while the parachutes of goatsbeard (*Tragopogon*) are noticeable on account of the extreme beauty of the feathery hairs which compose them [133]. The elegant fruits of clematis [134] are also wind-dispersed. Of tufted seeds it may suffice to mention willow (*Salix*) [148], cotton (*Gossypium*), and willow herb (*Epilobium*) [149].

The Ant as a Farmer. The chief groups of animals which unconsciously assist plants to colonise in favourable places are insects, birds, and mammals.

In warmer climates than our own there are several species of ants which may almost be described as farmers, since they collect and store various grains and seeds for consumption during hard times. A certain proportion of these must frequently escape being eaten and have the opportunity of growing up into young plants.

A very extraordinary case is afforded by the seeds of violets and pansies, each of which possesses a small fleshy knob (caruncle), which serves as a sweet and toothsome food that appeals to the taste of certain ants [150]. They are thus tempted to carry off these seeds, which remain quite uninjured when their little knobs have been gnawed away, and germinate if surrounding conditions are favourable.

The earth which often clings to the feet and feathers of birds, especially those which seek their food in damp places, often contains large numbers of small seeds, which thus stand a chance of getting carried to spots where they may successfully germinate and grow up. But a more frequent and more important case is that of succulent fruits, such as grapes, sloes, and a large assortment of berries, which attract birds by their often brilliant colours and minister to their appetites. In such fruits we find that the seeds are commonly protected by strong coverings, which escape the processes of digestion and are voided in a fit state for germination.

How Plants Distribute their Fruit. Many of the brightly coloured edible fruits of hot climates appeal to monkeys as much as birds, and thus get their seeds distributed in similar fashion. We also find a great variety of fruit and seed upon plants of low stature, provided with devices of various kinds by which they are enabled to cling to the coats of their unconscious friends.

It has been estimated that some 10 per cent. of all flowering plants produce fruits provided with hooks or spines by which they easily get attached to fur or hair. Familiar examples among our native plants are burdock (*Arctium lappa*) [151], agrimony (*Agrimonia eupatoria*) [152], avens (*Geum urbanum*) [153], and cleavers or goose-grass (*Galium aparine*). Some arrangements of the kind possessed by foreign forms are of truly formidable nature, such as the strong curved hooks of martynia [154], native to Louisiana, and the numerous formidable claws of harpagophyton [155], a plant which flourishes in South Africa, and is said to be fatal to the lion by producing festering sores.

Nature's Ingratitude. We also find that the spiked iron balls known as caltrops, which mediæval generals scattered on the ground for the entertainment of hostile cavalry, have been anticipated by some plants for the more useful purpose of dispersing their fruits. In Hungary and elsewhere, for example, there are forms (species of *Tribulus*) in which the fruits break up into pieces that lie on the ground and are liable to penetrate the feet of sheep and horned cattle by means of a sharp, brittle spine which sticks up from each of them [156]. After being carried away, the seed-containing part breaks off, while the spine remains embedded in the foot of the friendly animal, setting up a painful, festering wound—a very ungrateful return for services rendered.

Sticky Fruits are provided with sticky patches or hairs which easily adhere to the coats of passing animals. Typical examples are a kind of sage (*Salvia glutinosa*), and plumbago [157], a plant often grown in greenhouses in this country. It may be well to add that hooked and sticky fruits often attach themselves to the feathers of birds as well as to the fur of mammals.

Continued

OF FIRST VOLUME